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Economic Impact of Implementing RACT Guidelines in the State of Tennessee

Booz-Allen and Hamilton, Inc, Florham Park, NJ

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16. ABSTRACT

The major objective of the contract effort was to determine the direct economic impact of implementing RACT standards in Tennessee. The study is to be used primarily to assist EPA and state decisions on achieving the emission limitations of the RACT standards.

The economic impact was assessed for the following 13 RACT industrial categories: surface coatings (cans, coils, paper, fabrics, metal furniture, large appliances); solvent metal cleaning; bulk gasoline terminals; refinery systems; bulk gasoline plants; storage of petroleum liquids in fixed roof tanks; gasoline dispensing stations--Stage I; and use of cutback asphalt.

The scope of this project was to determine the costs and direct impact of control to achieve RACT guideline limitations for these 13 industry categories in Tennessee. Direct economic costs and benefits from the implementation of RACT limitations were identified and quantified while secondary impacts (energy, employment, etc.) are addressed, they were not a major emphasis in the study.

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ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES IN THE STATE OF TENNESSEE

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TO STATES AND EPA CARRYING OUT REQUIREMENTS
OF CLEAN AIR ACT AND APPLICABLE FEDERAL
AND STATE REGULATIONS

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
AIR & HAZARDOUS MATERIALS DIVISION
ATLANTA, GEORGIA 30308

EPA Project Officer: Winston Smith

From:

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April, 1979

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1. EXECUTIVE SUMMARY

This chapter summarizes the major elements and most significant findings of this study to determine the economic impact of implementing Reasonably Available Control Technology (RACT) guidelines for volatile organic compounds for thirteen industrial categories in the state of Tennessee. Further discussion and data are presented in detail in the subsequent chapters of the report. This Executive Summary is divided into three sections:

- Objectives, Scope and Approach
- Statewide Aggregate Economic Impact for the 13 RACT Guidelines
- Economic Implications of Each RACT Guideline.

1.1 OBJECTIVES, SCOPE AND APPROACH

The Clean Air Act Amendments of 1977 required the states to revise their State Implementation Plans (SIPs) to provide for the attainment and maintenance of national ambient air quality standards in areas designated as nonattainment. The Amendments require that each state submit the SIP revisions to the U.S. Environmental Protection Agency (EPA) by January 1, 1979. These proposed regulations should contain an oxidant plan submission for major urban areas to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. The Amendments also require that the states identify and analyze the air quality, health, welfare, economic, energy and social effects of the plan provisions.

1.1.1 Objectives

The major objective of the contract effort was to assist the states in the determination of the direct economic impact of selected segments of their SIPs for six states (Alabama, Georgia, Kentucky, North Carolina, South Carolina and Tennessee) of Region IV of the U.S. Environmental Protection Agency. These studies will be used primarily to assist EPA and state decisions on achieving emission limitations.

1.1.2 Scope

The scope of this project for Tennessee was to determine the costs and direct impacts of control to achieve RACT guideline limitations in thirteen industrial categories. The impact was addressed for each industry and for each state so that the respective studies are applicable to individual state regulations. Direct economic costs and benefits from the implementation of the RACT guidelines were identified and quantified. While secondary (energy, employment, etc.) impacts were addressed, they were not a major emphasis in the study. In summary, direct economic impact analysis of each industrial category was aggregated on a statewide basis for the RACT categories studied.

In Tennessee, the economic impact was analyzed for the implementation of RACT guidelines for the following 13 industry categories:

- Suface coating of coils
- Surface coating of metal cans
- Surface coating of paper
- Surface coating of fabrics
- Surface coating of metal furniture
- Surface coating of large appliances
- Solvent metal cleaning
- Bulk gasoline terminals
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks
- Service stations--Stage I
- Use of cutback asphalt
- Miscellaneous refinery sources.

The major study guidelines in the determination of the economic impact of the RACT guidelines are discussed below.

- The emission limitations for each industrial category were studied at the control level established by the RACT guidelines. These are presented in Exhibit 1-1, on the following page.

- All costs and emission data were presented for 1977.

- Emissions sources included were existing stationary point sources in most[1] of the applicable industrial categories with potential VOC emissions greater than 25 tons per year in 3 urban counties that were classified as non-attainment for ozone.[2] In the rest of the state, only sources with greater than 100 tons/year of potential VOC emissions were included in the study.

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1. For some industrial categories such as, Service Stations and Solvent Metal Cleaning) size characteristics were used as the basis for inclusion, rather than emissions.

2. The urban non-attainment counties included: Davidson, Hamilton, and Shelby.

EXHIBIT 1-1(1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT
THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH
APPLICATION OF RACT FOR THIRTEEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	2.8
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Metal Furniture	
. Prime and topcoat or single coat	3.0
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional freeboard; chiller or carbon absorber. Follow suggested procedures to minimize carryout.
. Conveyorized degreaser	Provide cleaners over 2 square meters air/vapor interface with: refrigerated chillers; or carbon absorption system; drying tunnel or rotating basket; safety switches; covers. Follow suggested procedures to minimize carryout.
. Open top degreaser	Provide cleaners over 1 square meter open areas with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.
Petroleum Refinery Sources	
. Vacuum producing systems	No emissions of any noncondensible VOC from condensers, hot wells or accumulators to a firebox, incinerator or boiler.

EXHIBIT 1-1(2)
U.S. Environmental Protection Agency

Category	RACT Guidelines Emission Limitations[a]
. Wastewater separators	Minimize emissions of VOC by providing covers and seals on all separators and forebays and following suggested operating procedures to minimize emissions
. Process unit turnaround	Minimize emissions of VOC by depressurization venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until it's internal pressure is 136 kilo Pascals (17.7 psia) or less
Bulk Gasoline Terminals	Equipment such as vapor control system to prevent mass emissions of VOC from control equipment to exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Bulk Gasoline Plants	Provide submerged filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to fixed roof storage vessels with capacities greater than 42,000 gallons containing volatile petroleum liquids for which true vapor pressure is greater than 10.5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility
Use of Cutback Asphalt	The manufacture, mixing, storage, use or application may be approved where: long-life stockpile storage is necessary; the use or application is an ambient temperature less than 10°C (50°F) is necessary; or it is to be used solely as a penetrating prime coat

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a. Annotated description of RACT guidelines

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, U.S. Environmental Protection Agency, EPA-9[illegible]12-78-001, April 1978.

- Service stations were studied for the 3 urban non-attainment counties only. In these counties only service stations with annual throughput over 260,000 gallons and storage tank capacity over 2000 gallons were studied.

- Petroleum liquid storage tanks over 42,000 gallons capacity containing volatile petroleum liquids with vapor pressure greater than 1.52 psia were studied statewide. (With the exception of storage tanks used to store produced crude oil prior to lease custody transfer where a 420,000 gallon capacity applied).

- All gasoline terminals were studied statewide.

- Solvent metal cleaning operations were studied for the three counties designated as urban non-attainment areas for facilities with greater than 25 tons potential emissions and statewide for facilities with greater than 100 tons potential emissions.

- The use of cutback asphalt was studied statewide.

- The following volatile organic compounds were exempted:

  - Methane
  - Ethane
  - Trichlorotrifluorethane
  - 1,1,1-trichloroethane (methyl chloroform).[1]

- The final compliance timing requirement for implementation of controls to meet RACT emission limitations was as follows:

  - November 1, 1981 for add-on control system
  - November 1, 1981 for equipment modification
  - September 1, 1981 for low solvent coatings.

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[1] The exemption status of methyl chloroform under these guidelines may be subject to change.

1.1.3 Approach

The approach applied to the overall study was: a study team with technology and economic backgrounds utilized available secondary sources to estimate the emissions, statistics and costs for each RACT industrial category; then, the study team completed, calibrated and refined these estimates based on interviews with industry representatives in the state.

Because of the number of point sources and the data available in the state emission inventory, the methodology was specific for each RACT industrial category studied. However, the general methodology applied for two major classes of industrial categories was:

- Surface coating RACT industrial categories (cans, coils, fabrics, paper, metal furniture and large appliances)--The potentially affected facilities and emissions were obtained primarily from the Tennessee Department of Public Health and interviews. Therefore, the following general methodology was applied:
    - A list of potentially affected facilities was compiled from secondary reference sources.
    - Data from the Tennessee emission inventory were categorized and compiled for each RACT industrial category by the Tennessee Department of Public Health.
    - Firms not listed in the emission inventory were identified. These facilities were then contacted by the Tennessee Department of Public Health to determine their inclusion.
    - Emissions, emission characteristics, control options and control costs were studied for these firms known to be in a specific category.
    - Interviews were conducted by Booz, Allen to determine emissions (when not available), applicable control options and potential control costs.
    - The study team then evaluated the control cost to meet the RACT requirements and the potential emission reduction.

- Nonsurface coating RACT industrial categories (bulk gasoline plants, bulk gasoline terminals and refineries, service stations, fixed roof tanks and solvent metal cleaning)--Each category either represented an exhaustive list of potentially affected facilities or emissions data were not available (or categorized) for these types of sources. Therefore, the following generalized methodology was applied:
    - Industry statistical data were collected from secondary reference sources.
    - The Tennessee Department of Public Health identified facilities which would be affected by the proposed regulation for bulk gasoline plants, terminals and fixed roof tanks.
    - Emissions were estimated by applying relevant factors (e.g., emissions per facility or throughput) which have been determined by the EPA.
    - Control options and estimated costs to meet the RACT guidelines were reviewed.
    - Interviews were conducted to determine applicable associated control options and the cost of control.

1.1.4 Quality of Estimates

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented. In addition, the study team has categorically ranked by qualitative judgment the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")--study inputs with variation of not more than ± 25 percent
- Medium quality ("extrapolated data")--study inputs with variation of ± 25 to 75 percent
- Low quality ("rough data")--study inputs with variation of ± 50 to 150 percent.

Each of these data quality estimates is presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

1.2 STATEWIDE AGGREGATE ECONOMIC IMPACT FOR THE THIRTEEN RACT GUIDELINES

The implementation of RACT emission limitations for thirteen industrial categories in Tennessee involves an estimated $36 million capital cost and $8.4 million annualized cost per year. The net VOC emission reduction is estimated to be 29,000 tons annually from a 1977 baseline of 41,000 tons. Exhibit 1-2, on the following page, presents a quantitative summary of the emissions, estimated cost of control, cost indicators and cost effectiveness of implementing RACT guidelines for thirteen industrial categories.

- Approximately 1,000 facilities are potentially affected by the thirteen RACT guidelines in Tennessee.
  - Eighty percent of the potentially affected facilities are represented by the service station (800 facilities) industrial category.
  - Ten percent of the potentially affected facilities are represented by solvent metal cleaning.
  - Less than 5 percent (46 facilities) of the potentially affected facilities are represented by the six surface coating industrial categories (cans, paper, fabrics, coils, metal furniture and large appliances).
- In 1977, the estimated annual VOC emissions (including those already controlled) for the thirteen RACT industrial categories totalled approximately 41,000 tons.
  - Four gas marketing categories (tank truck loading terminals, bulk gas plants, fixed roof tanks and service stations) represented 31 percent of the total VOC emissions.
  - Solvent metal cleaning represented 16 percent of the total VOC emissions (from the thirteen RACT categories studied)
  - Refinery systems represented 2 percent of the total VOC emissions
  - Use of cutback asphalt represented 8 percent of the total VOC emissions.
  - Six surface coating categories represented 43 percent of the total VOC emissions.

EXHIBIT 1-2
U.S. Environmental Protection Agency
SUMMARY OF IMPACT OF IMPLEMENTING RACT
GUIDELINES IN 13 INDUSTRIAL CATEGORIES — TENNESSEE

Industry Category	Emissions				Cost of RACT Control		Cost Indicators		Cost Effectiveness
	Number of Facilities Potentially Affected	1977 VOC Emissions (tons/yr.)	Estimated VOC Emissions After Implementing RACT (tons/yr.)	Net VOC Emission Reductions (tons/yr.)	Capital Cost[a] ($ millions)	Annualized Cost (credit) ($ millions)	Annualized Cost as Percent of Value of Shipments[b] (percent)	Annualized Cost Per Unit Shipment (cost per unit)	Annualized Cost (credit) Per Ton of VOC Reduction ($ per tons/yr.)
Surface coating of cans	6	260	150	110	0.125	0.044	0.2	negligible	400
Surface coating of coils[c]	2	1,000	200	800	0.3	0.084	-	-	105
Surface coating of paper	9	12,000	2,280	9,720	14.2	4.2	1.0	increase of 1.0	370-493
Surface coating of fabrics	3	140	26	114	1.1	0.3	1.5	increase of 1.5 percent	2,200-2,900
Surface coating metal furniture	7	950	150	800	0.3	(0.05)	negligible	varies with area coated	(64)
Surface coating of large appliances	19	3,320	1,000	2,320	6.6	1.6	0.15	$0.40/household appliance	680
Solvent metal cleaning	100	6,650	5,350	1,300	0.9	0.07	<0.15	negligible	55
Refinery vacuum wastewater separators and turnarounds	1	870	260	610	0.01	0.003	negligible	negligible	5
Tank truck gasoline loading terminals	31	8,700	870	7,830	9.45	1.352	0.15	$0.0006/gal.	155
Bulk gasoline plants	2	40	10	30	0.03	0.007	0.5	$0.0021	245
Storage of petroleum liquids in fixed roof tanks	17	1,500	150	1,350	1.07	0.12	-	$0.0004/gal.	86
Service Stations (Stage I)	804	2,500	130	2,370	1.9	0.47	0.1	$0.001/gal.	186
Cutback Asphalt	d	3,080	1,540	1,540	[illegible]	0	0	0	0
TOTAL	1,000	41,010	12,116	28,894	36.065	8.4			

Note: Figures presented in this exhibit are rounded and approximated for comparison purposes.

a. Includes one time costs
b. Value of shipments represents the total value in the specific industry category for the state being studied.
c. All coil coating and magnet wire coating facilities have implemented controls prior to the RACT guidelines and are assumed within compliance.
d. Estimate use of cutback asphalt in 1977 was 15,000 tons.

Source: Booz, Allen & Hamilton Inc.

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- The net emission reduction achievable by implementing the thirteen RACT guidelines is estimated to be 28,894 tons annually. The approximate percent of the total VOC emissions reduced by implementing RACT by industrial category group is:
  - Surface coating categories - 53 percent of VOC emission reduction
  - Gas marketing categories - 40 percent of VOC emission reduction
  - Use of cutback asphalt - 5 percent of VOC emission reduction.
  - Solvent metal cleaning category - 4 percent of VOC emission reduction
  - Refinery vacuum systems - 2 percent of VOC emission reduction.
- The capital cost for the thirteen industrial categories to achieve the RACT guidelines is estimated to be $36.1 million.
  - The six industrial categories dealing with surface coatings (cans, coils, paper, fabrics, metal furniture and large appliances) represent approximately 63 percent of the total capital cost ($22.6 million) required for control.
  - The four RACT categories dealing with petroleum marketing (bulk gasoline plants, bulk gasoline terminals, fixed roof tanks and service stations) account for approximately $12.5 million (or 35 percent of the total) of the estimated capital cost.
- The annualized cost of the thirteen RACT industrial categories to achieve the RACT guidelines is estimated to be $8.4 million. In terms of cost indicators, the annualized compliance cost per value of shipments will have the largest effect on the following industrial categories:
  - Fabric coating -- the annualized costs represent approximately 1.5 percent of the affected value of shipments.

  - Paper coating--The annualized costs represent approximately 1.0 percent of the 1977 affected value of shipments.

  - Bulk gasoline plants--The annualized compliance costs represent approximately 0.5 percent of the affected value of shipments.

- Technology developments and delivery of equipment could present problems in achieving the 1982 timing requirements of the RACT guidelines.

  - Low solvent coating technology requires further development for cost- and energy-effective implementation of the RACT guidelines in the following industrial categories:

    - Surface coating of large appliances (high solids coatings have not been commercially proven)

    - Surface coating of cans (end sealing compound)

    - Surface coating of metal furniture (full color line is currently not available).

    - Surface coating of fabrics and paper (few water based coatings are available for substitution)

  - Equipment delivery and installation of control equipment were identified as potential problems in the following industrial categories:

    - Surface coating of paper
    - Solvent metal degreasing
    - Tank truck gasoline loading terminals
    - Surface coating of fabrics
    - Gasoline service stations.

- The implementation of the RACT guidelines is expected to create further concentration for industrial sectors requiring major capital and annualized cost increases for compliance. RACT requirements may have an impact on the market structure of the following RACT industrial categories:

  - Service stations
  - Surface coating of paper
  - Surface coating of fabrics.

- The implementation of the RACT guidelines for the thirteen industrial categories is estimated to represent a net energy savings of 17,670 equivalent barrels of oil annually; or 0.03 percent of the statewide energy demand for all manufacturing. Assuming a value of oil at $13 per barrel, this is an equivalent energy savings of $0.23 million annually. Exhibit 1-3, on the following page, presents the estimated change in energy demand from implementation of the RACT guidelines in Tennessee.

  - RACT compliance requirement for the six surface coating industrial categories (cans, coil, paper, fabrics, metal furniture, and large appliances) represent a net energy demand of approximately 61,000 equivalent barrels of oil annually.

  - RACT compliance requirements for the four industrial categories dealing with petroleum marketing (service stations, bulk gasoline terminals, fixed roof tanks and bulk gasoline plants) represent a net energy savings of approximately 78,900 barrels of oil annually. However, the control efficiency has not been fully demonstrated and these estimates are likely to overstate the achievable energy savings for bulk gasoline terminals and service stations.

EXHIBIT 1-3

U.S. Environmental Protection Agency

ESTIMATED CHANGE IN ENERGY DEMAND RESULTING FROM IMPLEMENTATION OF RACT GUIDELINES IN TENNESSEE

Industry Category	Energy Demand Change Increased (Decrease) (Equivalent barrels of oil)	Energy Demand Change Cost/(Savings)[a] ($ thousand)
Surface coating of cans	1,200	15.6
Surface coating of coils	None	None
Surface coating of paper	68,000	884
Surface coating of fabrics	630	8.2
Surface coating of metal furniture	(5,400)	(70.2)
Surface coating of large appliances	(3,430)	(44.6)
Solvent metal cleaning	200	2.6
Refinery systems	None	0
Tank truck gasoline loading terminals	(53,500)	(695.5)
Bulk gasoline plants	(200)	(2.6)
Storage of petroleum liquids in fixed roof tanks	(9,270)	(120.5)
Service stations (STAGE I)	(15,900)	(206.7)
Use of cutback asphalt	None	None
TOTAL	(17,670)	(229.7)

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a. Based on the assumption that the cost of oil is $13 per barrel.

Source: Booz, Allen & Hamilton Inc.

1.3 ECONOMIC IMPLICATIONS OF EACH RACT GUIDELINE

This section presents a summary of the economic impact for each of the 13 RACT industrail categories studied. Following this section is a series of summary exhibits which highlight the study findings for each industrial category.

1.3.1 Surface Coating of Cans

Currently there are six or seven can coating facilities in the state of Tennessee. Tennessee is not a major producer of cans.

The industry preferred method of control to meet the RACT requirements is to convert to low solvent (waterborne) coatings. However, low solvent coatings for end sealing compounds are presently not available and may not be available by 1982. To meet the RACT requirements, can manufacturers may convert three-piece can lines to waterborne coatings or install thermal incineration for controlling high solvent coatings. In addition, some three-piece can facilities may convert to two-piece for economic or market reasons which would have the effect of lower VOC emissions.

Emission controls are expected to cost the industry $125,000 in capital and $44,000 in annualized cost. This represents approximately 0.2 percent of the affected industry's value of shipments. No major employment, productivity or market structure changes are expected from the implementation of the RACT guideline.

The industry trend towards production of two-piece aluminum cans with print-only coatings (rather than print and varnish) is predicted to continue because of economic advantages and market demands. The conversion to print-only technology will reduce current VOC emissions. Because the industry is planning to convert some facilities to print-only technology in the near term, associated economic advantages of the conversion have not been included in the economic analysis of the RACT requirements.

1.3.2 Surface Coatings of Coils

There are at least two facilities potentially affected by the RACT guidelines for coil coating. For these firms the estimated capital cost for control is $0.3 million and the annualized cost is $84,000. No major market structure, employment or productivity impacts are anticipated.

1.3.3 Surface Coating of Paper

This study covered nine plants identified from the RACT requirements for paper coaters. There may be additional plants in the state of Tennessee which would be affected by the RACT guidelines and are not included in this analysis. Excluded from this study are facilities engaged in publishing, who may coat paper as a segment of the processing line. The study assumes that these facilities would fall under other RACT guidelines currently being developed, such as Graphic Arts. Further definition of the paper coating category should be established prior to enforcement.

The retrofit situations and installation costs for add-on controls are highly variable. Based on these variations, the estimated capital cost to the known affected industry is between $13.7 million and $14.8 million, with an annualized cost of $3.6 million to $4.8 million (approximately 1.0 percent of the affected value of shipments).

Assuming 35 percent heat recovery, the annual energy requirements are expected to increase by approximately 68,000 equivalent barrels of oil per year. Energy consumption may decrease if more efficient recovery of incinerator heat is possible.

Incinerator equipment manufacturers have stated that there may be significant problems in meeting the anticipated demand for high heat recovery incinerators on a nationwide basis.

1.3.4 Surface Coating of Fabrics

There are at least three firms in Tennessee identified as coaters of fabric and affected by the proposed RACT guidelines. In addition there may be more potentially affected facilities. It is estimated that these 3 facilities will be required to invest an estimated $1.1 million in capital and approximately $0.3 million in annualized cost to meet RACT limitations.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guidelines.

1.3.5 Surface Coating of Metal Furniture

There are at least seven facilities in Tennessee identified as manufacturers and coaters of metal furniture, which would be affected by the proposed limitations for the RACT industrial category. None of the facilities are believed to have controls which would meet the proposed limitations.

To meet the RACT requirements, these facilities will need to invest approximately $300,000 in capital, and the annualized savings of control could be up to $50,000.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guidelines.

To meet the RACT requirements, the low solvent coating materials may not totally be available in the quality, color variety or specifications of each of the manufacturers. The development of totally suitable coating materials (or changes in current manufacturing requirements) is the key to successful implementation of the RACT requirements within the given time limitations.

1.3.6 Surface Coating of Large Appliances

There are an estimated 19 large appliance manufacturing facilities in Tennessee potentially affected by the RACT guidelines. These manufacturers would be required to invest approximately $6.6 million in capital and incur additional annualized costs of $1.6 million (approximately 0.15 percent of industry statewide value of shipments).

Assuming a "direct cost pass-through," the cost increase for household appliances relates to a price increase of approximately $0.40 per unit. No major productivity, employment or market structure dislocations appear to be associated with implementation of the RACT guidelines.

The high solids (greater than 62 percent by volume) topcoat application technique preferrred by the industry has not been proven under normal operating conditions although it appears to be technically feasible.

1.3.7 Solvent Metal Cleaning

This category includes equipment to clean the surface for removing oil, dirt, grease and other foreign material by immersing the article in a vaporized or liquid organic solvent. The cleaning is done in one of three devices: a cold cleaner, an open top vapor degreaser, or a converyorized degreaser. This type of cleaning is done by many firms in many different types of industries.

Implementation of the proposed regulations in Tennessee will affect an estimated 834 cleaning operations in 100 facilities. The regulation is expected to have a negligible economic effect on industry because of the relatively minor changes required. For Tennessee, the 834 cleaners potentially affected represent a capital cost of 0.9 million and an annualized cost of $70,000 (<0.001 percent of industry value of shipments).

Because of the large number of degreasers nationwide that require retrofit to meet RACT and the inability of manufacturers to provide equipment on such a large scale, it is doubtful if all degreasers nationwide can be retrofitted within the 1982 timeframe.

No major productivity, employment and market structure dislocations are expected to result from RACT implementation.

1.3.8 Refinery Vacuum Systems, Wastewater Separators and Process Unit Turnarounds

There is only one refinery facility in the state of Tennessee potentially affected by the proposed RACT guidelines. The RACT requirements represent a capital investment of approximately $11,000 and an annualized cost of approximately $3,100.

No significant productivity, employment or market structure dislocations should be associated with the implementation of the RACT guideline.

1.3.9 Tank Truck Gasoline Loading Terminals

There are an estimated 31 facilities in the state of Tennessee potentially affected by the tank truck gasoline loading terminal limitation requirements. Emission control of these facilities is expected to require a capital investment of $9.5 million. Product recovery of gasoline will be accrued to bulk terminal operations not only from bulk terminal emission control installations but also from the recovery of vapors from service stations and bulk gasoline plants. Based on this savings, the net annualized cost for implementation of RACT for bulk gasoline loading terminals is estimated to be $1.5 million (approximately 0.15 percent of the value of the shipments). Assuming a direct cost pass-through this represents a cost of 0.26 per gallon throughput.

No significant productivity, employment or market structure dislocations should be associated with implementing the RACT guidelines.

1.3.10 Bulk Gasoline Plants

This industry is characterized by many small plants. Of these plants, only a few percent are either new or modernized. The majority of the plants are over 20 years old. Most bulk plants are located in rural areas where implementation of RACT to stationary sources is not required in the state of Tennessee.

To meet the RACT requirements, only 2 bulk gas plants in the urban nonattainment areas must be equipped with vapor balance and submerged fill systems. This recommended control system is not cost-effective for the bulk plant operator as most of the economic credit (for recovered vapors) would be accrued to a bulk terminal or refinery.

The estimated capital cost and annualized cost to meet compliance requirements for the 2 facilities represent $28,000 and $7,000 (approximately 0.5 percent of affected plant's value of shipments), respectively. For these facilities, the price of gasoline (assuming a "direct cost pass-through") would be increased $0.002 per gallon. In urban areas, the bulk gasoline plant markets have been declining because of competition from retailers and tank truck terminals, and is expected to continue to decline regardless of the RACT guidelines.

1.3.11 Storage of Petroleum Liquids in Fixed Roof Tanks

There are an estimated 17 fixed roof tanks in the 3 urban county nonattainment areas in the state of Tennessee which would have to equipped with a internal floating roof to comply with the proposed RACT requirements. These VOC emissions (1977) for these tanks are estimated to be approximately 1,500 tons.

These tanks are primarily owned by major oil companies and bulk gasoline tank terminal companies. The capital cost to equip these tanks with a single seal floating roof is estimated to be $1.1 million. The estimated annualized cost is $0.12 million, which would represent a price increase (assuming "direct cost pass-through") of less than $0.001 per gallon of throughput .

No significant productivity, employment or market structure changes should be associated with the implementation of the RACT guideline.

Implementation of the RACT guideline is estimated to represent a net energy savings of 9,270 equivalent barrels of oil annually (assuming 90 percent control efficiency).

1.3.12 Service Stations

There are approximately 800 gasoline dispensing facilities in the 3 urban county nonattainment areas of Tennessee. The implementation of submerged fill and vapor balancing at these stations is estimated to be $1.9 million in capital. The annualized cost of compliance of $0.47 million represents an average cost increase of approximately $0.001 per gallon; however, larger stations will experience a much smaller unit cost increase. Some service stations could experience loss of business while vapor control systems are being installed.

Implementation of the RACT guidelines may accelerate the trend to high throughput stations because of the increasing overhead costs. However, the RACT guidelines are not expected to cause major productivity and employment dislocations to the industry as a whole.

It is estimated that implementing RACT guidelines for service stations in Tennessee will result in a net energy savings equivalent to 15,900 barrels of oil per year, assuming 95 percent recovery of gasoline. This assumed control efficiency has not been fully demostrated. Only a small percent of the economic benefit from the recovered gasoline vapors will directly accrue to the service stations.

1.3.13 Use of Cutback Asphalt

In 1977, it is estimated that 15,000 tons of cutback asphalt was utilized in Tennessee. Replacement of the solvent-based asphalt with asphalt emulsion will cause no dislocation in employment or worker productivity. Capital and training cost investment is estimated at $30,000. No change in paving cost are expected from the implementation of the RACT guideline.

It is anticipated that sufficient lead time is available to assure an adequate supply of asphalt emulsion to meet the increased demand and provide training for municipal employees.

* * * *

A summary of the direct economic implications of implementing RACT in each of the 12 industrial categories studied is presented in Exhibit 1-4 through 1-16, on the following pages.

EXHIBIT 1-4(1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR CAN MANUFACTURING
PLANTS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are six or seven can manufacturing facilities; however, the largest is being shut down for economic reasons
Indication of relative importance of industrial section to state economy	1977 value of shipments was $40 million to $45 million. Industry is closely related to state's food and beverage industries
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
1977 VOC emissions (actual)	260 tons per year excluding 455 tons at plant being shut down
Industry preferred methods of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	75 percent of cans coated with low solvent coatings; 25 percent of coated cans requiring incinerator for control

Affected Areas in Meeting RACT	Discussion
Capital investment statewide (excluding shut down facility)	$125,000 (less than 5 percent of current annual capital appropriations for the industry
Annualized cost (statewide excluding shut down facility	$44,000 (approximately 0.3 percent of the industry's 1977 statewide value of shipments, excluding the shutdown plant)
Price	Assuming a "direct cost pass through" less than $0.0001 can increase (based on a can value of $0.075 per can)
Energy	Increase of 1,000 to 1,500 equivalent barrels of oil annually for operation of facilities that have to utilize incinerators
Productivity	No major impact
Employment	No major impact

EXHIBIT 1-4(2)

U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Market structure	Accelerated technology conversion to two-piece cans, further concentration of sheet coating operations into larger facilities
RACT timing requirements (1982)	Low solvent coating volume requirements and FDA approval may require some facilities to meet the RACT requirements with incinerations (rather than low solvent coating technology)
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	150 tons per year (21 percent of 1977 emission level or 58 percent of emissions from affected plants)
Cost effectiveness of RACT control excluding shut down facility	$390 to $400 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-5
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are two coil coating facilities with two lines potentially affected by the coil coating RACT guideline in Tennessee
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative type incinerators
1977 VOC emissions (actual)	Approximately 1,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumes method of control to most RACT guidelines	Regenerative thermal incineration and low solvent coatings

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$0.3 million incremental capital required by two firms based on model plant costs
Annualized Cost (statewide)	$84,000
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	Some captive coil coating operations not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements	There may be delivery and installation problems if major coating industry sectors who require incinerators, order and install similar equipment in the same time frame
Problem area	Low solvent coating technology is currently inadequate to meet product requirements in all applications
VOC emission after control	Approximately 200 tons per year (20 percent of 1975 VOC emission level)
Cost effectiveness of control	$84 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-6(1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	Nine plants in the state are expected to be affected by these regulations. However, if this category were to be interpreted to include all types of paper coating, including publishing, far more firms would be affected.
Indication of relative importance of the industrial sector to the state economy	The 1977 value of shipments of these nine plants is estimated to be about $443 million. They are estimated to employ 6310 people.
Current industry technology trends	Gravure coating replacing older systems.
1977 VOC emissions (actual)	Approximately 12,008 tons per year were identified from nine plants affected. All of these are applicable under RACT.
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent use is increasing, progress is slow. Add-on control systems will probably be used.
Assumed method of control to meet RACT guidelines	Thermal incineration with primary heat recovery.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $13.7 million to $18.2 millio depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected paper coaters.
Annualized cost (statewide)	$3.6 million to $4.8 million annually. This represents 0.8 to 1.1 percent of the value of shipments for the nine firms directly affected.
Price	Assuming a "direct cost pass-through"-- 0.8 to 1.1 percent at the three affected firms.

EXHIBIT 1-6(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Energy	Assuming 35 percent heat recovery from the incineration system, annual energy requirements are expected to increase by approximately 68,000 equivalent barrels of oil.
Productivity	No major impact.
Employment	Moderate impact.
Market structure	Larger firms are likely to absorb sales of marginally profitable firms.
RACT timing requirements (1982)	RACT guideline needs clear definition for enforcement. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Problem areas	Retrofit situations and installation costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 2,281 tons/year (19 percent of 1977 VOC emission level from three affected plants).
Cost effectiveness of control	\$370 - \$493 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-7(1)

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	Three plants in the state's non-attainment areas are expected to be affected by these regulations.
Indication of relative importance of industrial sector to the state economy	The 1977 value of shipments of these plants is estimated to be about $20.2 million They are estimated to employ 300 people in fabric coating operations.
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants are only marginally competitive now.
1977 VOC emissions (actual)	Current emissions are estimated at about 140 tons/year.
Industry preferred method of VOC control to meet RACT guidelines	Not yet decided
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary heat recovery.
Affected Areas in Meeting RACT	**Discussion**
Capital investment (statewide)	Estimated to be $0.9 million to $1.2 million depending on retrofit situations.
Annualized cost (statewide)	$250,000 to $330,000 annually.
Price	Assuming a "direct cost pass-through"-- 1.2 to 1.6 percent.
Energy	Assuming 35 percent heat recovery, annual energy requirements are expected to increase by approximately 970 equivalent barrels of oil.
Productivity	No major impact.
Employment	No major impact.
Market structure	No major impact.

EXHIBIT 1-7(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
RACT timing requirements (1982)	RACT guidelines need clear definition for rule making. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Problem areas	Retrofit situations and installation costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 36 tons/year (19 percent of 1977 VOC emission level from affected plants).
Cost effectiveness of control	$2,200 to $2,900 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-8(1)

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURACE COATING OF METAL FURNITURE IN TENNESSEE

Current Situtation	Discussion
Number of potentially affected facilities	There are seven metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $109 million industry-wide and approximately $58 million for seven affected facilities
1977 VOC emissions (actual)	953 tons per year
Industry preferred method of VOC control	Low solvent coatings
Assumed method of control to meet RACT guidelines	Low solvent coatings
Affected Areas in Meeting RACT	**Discussion**
Capital investment (statewide)	$305,000
Annualized savings (statewide)	$51,000 which represents 0.05 percent of the industry's 1977 value of shipments
Price	Increase from a few cents to over $1/unit depending on the surface area coated
Energy savings	5,400 equivalent barrels of oil per yr.
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Companies using a variety of colors may face a problem finding suitable low solvent coatings

EXHIBIT 1-8(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	151 tons per year (approximately 16 percent of current emissions level)
Cost effectiveness of RACT	$64 annualized savings per annual ton of VOC emissions reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-9

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are 20 major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments is approximately $1.0 billion and represents 7 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	3,323 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Assumed method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$6.6 million
Annualized cost (statewide)	$1.6 million which represents 0.15 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.40/unit for household appliances (based on a price of $183 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 3,430 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements	Possible problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	997 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$680 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 1-10(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected cleaners	834 cleaners
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is 8.4 billion.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	6,646 tons/year (including solvents classified as exempt)
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control to meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$0.9 million
Annualized cost (statewide)	$70,000 million (less than percent of the 1977 affected facilities' value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price effect expected to be less than 0.005 percent for affected facilities.
Energy	Less than 300 equivalent barrels of oil per year increase
Productivity	5-10 percent decrease for manually operated degreasers. Will not effect conveyorized cleaners.

EXHIBIT 1-10(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modifications
Problem areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	5,348 tons/year (80 percent of 1977 VOC emission level--however, this does not include emission controls for exempt solvents)
Cost-effectiveness of RACT control	$55 annualized cost per ton of emissions reduced

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-11

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	1
Indication of relative importance of industrial section to state economy	1977 industry sales were $181 million. The estimated annual crude oil throughput was 13 million barrels
Current industry technology trends	No controls have been implemented on wastewater separation area
1977 VOC actual emissions	873 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Vapor recovery of emissions by piping emissions to refinery fuel gas system or flare and covering wastewater separators
Estimated method of VOC control to meet RACT guidelines	Vapor recovery by piping emissions from vacuum producing systems to refinery fuel gas system, cover wastewater separator, pipe emissions from process units to flare

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	11,000
Annualized cost (statewide)	3,100
Price	No major impact
Energy	No major impact
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	264 tons per year
Cost effectiveness of control	$5 annualized cost/annual ton of VOC reduction

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Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-12

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	31
Indication of relative importance of industrial section to state economy	1977 industry sales were $1.036 billion. The estimated annual throughput was 2.44 billion gallons
Current industry technology trends	New terminals are currently being designed with vapor recovery equipment
1977 VOC actual emissions	3,775 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Submerge or bottom fill and vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$9.453 million
Annualized cost (statewide)	$1.552 million (approximately 0.15 percent of value of shipments)
Price	Assuming a direct cost passthrough $0.0006 per gallon
Energy	Assuming full recovery of gasoline—net savings of 53,500 barrels annually from terminal emissions
Productivity	No major impact
Employment	No direct impact
Market structure	No direct impact
Problem area	Gasoline credit from vapors from bulk gasoline plants and gasoline service stations require uniform RACT requirements through the state
VOC emission after control	870 tons per year
Cost effectiveness of control	$155 annualized cost/annual ton of VOC reduction from terminals including gasoline credit from vapors returned from bulk gasoline plants and gasoline service stations

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-13

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR AFFECTED BULK GASOLINE PLANTS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	2
Indication of relative importance of industrial section to state economy	Industry sales from affected bulk plants were 1.36 million. The estimated annual throughput was 3.2 million gallons.
Current industry technology trends	Only small percent of industry has new/modernized plants
1977 VOC actual emissions	40 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerge fill and vapor balancing

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$27,700
Annualized cost (statewide)	$7,000 (approximately 0.5 percent of value of shipments)
Price	Assuming a "direct cost passthrough" industrywide—$0.0021 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 200 barrels annually
Productivity	No major impact
Employment	No major impact; however, for plants closing, potential average of 5 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk plants today are marginal operations; further cost increases could result in plant closings
Problem areas	Severe economic impact for small bulk plant operations. Control efficiency of cost effective alternative has not been fully demonstrated
VOC emissions after control	10 tons per year
Cost effectiveness	$245 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-14

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUID IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected storage tanks	17
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 276 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	1,508 tons per year
Preferred method of VOC control to meet RACT guidelines	Single seal internal floating roof
Affected Areas in Meeting RACT	**Discussion**
Capital investment (statewide)	$1.074 million
Annualized cost (statewide)	$117,000
Price	Assuming a "direct cost" passthrough—less than $0.0004 per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 9,270 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Potential availability of equipment to implement RACT standard
VOC emission after control	150 tons per year
Cost effectiveness of control	$86 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 1-15

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	804 in the 3 urban non-attainment counties.
Indication of relative importance of industrial sector to county economy.	3 county industry sales from the affected facilities are $0.330 million with a yearly throughput of 0.651 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of stations in U.S. are predicted to become totally self-service
1977 VOC emissions (actual)	2514 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance
Assumed method of control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (3 counties)	$1.9 million
Annualized cost (3 counties)	$0.47 million (approximately 0.1 percent of the value of gasoline sold)
Price	Assuming a "direct cost pass-through"--less than $0.001 per gallon of gasoline sold in the 3 counties.
Energy	Assuming full recovery: 770,300 gallons/year (15,900 barrels of oil equivalent) saved[a]
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations (i.e., marginal operations may opt to shut down)

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[a] One gallon of gasoline has 125,000 BTU's. One barrel of oil equivalent has 6,050,000 BTU's.

EXHIBIT 1-16

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF TENNESSEE

Current Situation	Discussion
Use of cutback asphalt	In 1977, use of cutback asphalt was 14,956 tons in the state.
Indication of relative importance of industrial sector to state economy	1977 sales of cutback asphalt were estimated to be $1.4 million.
Current industry technology trends	Nationally, use of cutback asphalt has been declining.
1977 VOC emissions (actual)	3080 tons annually; 1,540 of which would be controled under the proposed regulations.
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions
Assumed method of control to meet RACT guidelines	Replace with asphalt emulsions
Affected Areas in Meeting RACT	**Discussion**
Capital investment	$0.03 million
Annualized cost	No change in paving costs are expected.
Price	No change in paving costs are expected.
Energy	No savings to user[a]
Productivity	No major impact
Employment	No major impact

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[a] It is estimated that an energy savings of 14,989 barrels of oil equivalent could accrue to the manufacturer. The total energy associated with manufacturing, processing and laying one gallon of cutback is approximately 50,200 BTUs/gallon. For emulsified asphalts, it is 2,830 BTUs/gallon. One barrel of oil equivalent is assumed to have 6.05 million BTUs, and one ton of cutback asphalt is assumed to have 256 gallons.

2.0 INTRODUCTION AND OVERALL STUDY APPROACH

This chapter presents an overview of the study's purpose, scope and methodology. It is divided into six sections:

- Background
- Summary of State Implementation Plan revisions and state's need for assistance
- Scope
- Approach
- Quality of estimates
- Definition of terms used.

Each of these sections is discussed below.

The approach and quality of estimates is discussed in detail in each of the respective chapters dealing with the specific industrial categories affected by the volatile organic compounds control regulations.

2.1. BACKGROUND

The Clean Air Act Amendments of 1977 required the states to revise their State Implemtation Plans (SIPs) to provide for the attainment and maintenance of national ambient air quality standards in areas designated as non-attainment. The Amendments require that each state submit the SIP revisions to the U.S. Environmental Protecton Agency (EPA) by January 1, 1979. These proposed regulations should contain an oxidant plan submission for major urban areas to reflect the application of Reasonably Available Control Technology (RACT) to stationary sources for which the EPA has published guidelines. The Amendments also require that the states identify and analyze the air quality, health, welfare, economic, energy and social effects of the plan provisions.

Under the drection of Region IV, the EPA contracted with Booz, Allen & Hamilton Inc. (Booz, Allen) to assist the states of Alabama, Georgia, Kentucky, North Carolina, South Carolina and Tennessee in analyzing the economic, energy and social impacts of the SIP revisions proposed by these states. The assignment was initiated on September 28, 1978, and, as a first step, the proposed SIP revisions and the type of assistance desired by each state were reviewed.

After a review with each of the states and EPA Region IV representatives, a work scope was defined that would include in the study an analysis of the direct economic and energy impacts for those industrial segments most likely to have a significant impact at the statewide level. For the most part this included industrial categories that had more than a few facilities potentially affected. The next section discusses those specific industrial categories included in this work scope.

2.2 SUMMARY OF PROPOSED SIP REVISIONS IN TENNESSEE AND THE STATE'S NEED FOR CONTRACTOR SUPPORT

Tennessee has proposed statewide regulations to reduce volatile organic compound (VOC) emissions by implementing the Reasonably Available Control Technology (RACT) guidelines developed by the EPA for existing stationary sources. The state is also studying implementation of motor vehicle inspection/maintenance programs in the non-attainment areas. In addition, the state has proposed revisions to total suspended particulates (TSP) and sulfur dioxide emission standards.

The state officials were interviewed to determine their need for support in analyzing the economic impact of the SIP revisions. The analysis of implementing the RACT guidelines for reducing VOC emissions was expressed as the fundamental concern. Specifically, the state needed assistance in the analysis of 13 of the 15 industrial categories for which the EPA has published RACT guidelines. These 13 RACT industrial categories are described in the next section. The other two industrial categories (surface coating of automobiles and magnet wire insulation) were excluded from this study because none or a very limited number of sources were affected by the proposed regulation in those categories. Although the cost impact in those categories excluded might be significant for an individual firm studied, it is unlikely that the economic or energy impact at the macrolevel (statewide) would be significant. The state officials also wanted to include a large chemical plant in the study.

2.3 SCOPE

The primary objective of this study is to determine the costs and impact of compliance with the proposed SIP revisions for six states in EPA Region IV. The study will emphasize the analysis of direct economic costs and benefits of the proposed SIP revisions. Secondary (employment and energy) impacts will also be addressed but are not the major study emphasis.

In Tennessee, the economic impact will be analyzed for the implementation of RACT guidelines to reduce VOC emissions from the following 13 industry categories:

- Surface coating of coils
- Surface coating of metal cans
- Surface coating of paper
- Surface coating of fabrics
- Surface coating of metal furniture
- Surface coating of large appliances
- Solvent metal cleaning
- Bulk gasoline terminals
- Bulk gasoline plants
- Storage of petroleum liquids in fixed roof tanks
- Service stations -- Stage I
- Use of cutback asphalt
- Miscellaneous refinery sources.

The major study guidelines in the determination of the economic impact of the RACT guidelines are discussed below.

- The emission limitations for each industrial category will be studied at the control level established by the RACT guidelines. These are presented in Exhibit 2-1, on the following page.

- All costs and emission data were presenced for 1977.

EXHIBIT 2-1(1)
U.S. Environmental Protection Agency
LISTING OF EMISSION LIMITATIONS THAT REPRESENT
THE PRESUMPTIVE NORM TO BE ACHIEVED THROUGH
APPLICATION OF RACT FOR THIRTEEN INDUSTRY CATEGORIES

Category	RACT Guideline Emission Limitations[a] Surface Coating Categories Based on Low Organic Solvent Coatings (lbs. solvent per gallon of coating, minus water)
Surface Coating Of:	
Cans	
. Sheet basecoat (exterior and interior) Overvarnish Two-piece can exterior (basecoat and overvarnish)	2.8
. Two and three-piece can interior body spray Two-piece can exterior end (spray or rollcoat)	4.2
. Three-piece can side-seam spray	5.5
. End sealing compound	3.7
Coils	
. Prime and topcoat or single coat	2.6
Paper	2.9
Fabrics and vinyl coating	
. Fabric	2.9
. Vinyl	3.8
Metal Furniture	
. Prime and topcoat or single coat	3.0
Large appliance	
. Prime, single or topcoat	2.8
Solvent Metal Cleaning	
. Cold cleaning	Provide cleaners with: cover; facility to drain clean parts; additional freeboard; chiller or carbon absorber. Follow suggested procedures to minimize carryout.
. Conveyorized degreaser	Provide cleaners over 2 square meters air/vapor interface with: refrigerated chillers; or carbon absorption system; drying tunnel or rotating basket; safety switches; covers. Follow suggested procedures to minimize carryout.
. Open top degreaser	Provide cleaners over 1 square meter open areas with: safety switches; powered cover; chiller; carbon absorber. Follow suggested procedures to minimize carryout.
Petroleum Refinery Sources	
. Vacuum producing systems	No emissions of any noncondensible VOC from condensers, hot wells or accumulators to a firebox, incinerator or boiler.

EXHIBIT 2-1(2)
U.S. Environmental Protection Agency

Category	RACT Guidelines Emission Limitations[a]
. Wastewater separators	Minimize emissions of VOC by providing covers and seals on all separators and forebays and following suggested operating procedures to minimize emissions
. Process unit turnaround	Minimize emissions of VOC by depressurization venting to vapor recovery, flare or firebox. No emissions of VOC from a process unit or vessel until it's internal pressure is 136 kilo Pascals (17.7 psia) or less
Bulk Gasoline Terminals	Equipment such as vapor control system to prevent mass emissions of VOC from control equipment to exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Bulk Gasoline Plants	Provide submerged filling and vapor balancing so that VOC emissions from control equipment do not exceed 80 milligrams per liter (4.7 grains per gallon) of gasoline loaded
Storage of Petroleum Liquids in Fixed Roof Tanks	Provide single seal and internal floating roof to fixed roof storage vessels with capacities greater than 42,000 gallons containing volatile petroleum liquids for which true vapor pressure is greater than 10.5 kilo Pascals (1.52 psia)
Service Stations (Stage I)	Provide submerged fill and vapor balance for any stationary storage tank located at a gasoline dispensing facility
Use of Cutback Asphalt	The manufacture, mixing, storage, use or application may be approved where: long-life stockpile storage is necessary; the use or application is an ambient temperature less than 10°C (50°F) is necessary; or it is to be used solely as a penetrating prime coat

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[a] Annotated description of RACT guidelines

Source: *Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources*, U.S. Environmental Protection Agency, EPA-90512-78-001, April 1978.

- Emissions sources included were existing stationary point sources in some of the applicable industrial categories[1] with potential VOC emissions greater than 25 tons per year in 3 urban counties that were classified as non-attainment for ozone.[2] In the rest of the state, only sources with greater than 100 tons/year of potential VOC emissions were included in the study.

- Service stations and the use of cutback asphalt were studied for the 3 urban non-attainment counties only. Only service stations with annual throughput over 260,000 gallons and storage tank capacity over 2,000 gallons were studied.

- All petroleum liquid storage tanks over 42,000 gallons capacity were studied statewide.

- Solvent metal cleaning operations were studied statewide under the following guidelines. In rural areas, only those sources with potential emissions greater than 100 tons were studied. In urban non-attainment areas, the estimated number of sources with potential emissions greater than 25 tons per year was studied.

- The following volatile organic compounds were exempted:

    - Methane
    - Ethane
    - Trichlorotrifluorethane
    - 1,1,1-trichloroethane (methyl chloroform).[3]

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[1] Surface coating, bulk plants and miscellaneous refinery sources.

[2] The urban non-attainment counties include: Davidson, Hamilton and Shelby.

[3] The exemption status of methyl chloroform under these guidelines may be subject to change.

- The final compliance timing requirement for implementation of controls to meet RACT emission limitations was as follows:
    - November 1, 1981 for add-on control systems
    - November 1, 1981 for equipment modification
    - September 1, 1981 for low solvent coatings.

2.4 APPROACH

This section describes the overall approach and methodology applied in this assignment. In general, the approach varied for each state and also for each industrial category studied. This section specifically describes the overall approach that was applied for the State of Tennessee. The methodology applied to determine the economic impact for each industrial category in Tennessee is described in further detail in the first section of each chapter dealing with the specific industry category.

There are five parts to this section to describe the approach for determining estimates of:

- Industry statistics
- VOC emissions
- Process descriptions
- Cost of controlling VOC emissions
- Comparison of direct costs with selected direct economic indicators.

2.4.1. Industry Statistics

The assembly of economic and statistical data for each industrial category was an important element in establishing the data base that was used for projection and evaluation of the emissons impact. Some of the major variables for each industrial category were:

- Number of manufacturers
- Number of employees
- Value of shipments
- Number of units manufactured
- Capital expenditures
- Energy consumption
- Productivity indices

- Current economic (financial) status
- Industry concentration
- Business patterns (small vs. large; downstream integration)
- Age distribution of facilities
- Future trends and developments.

Some of the industrial categories studied cover a large number of potentially affected facilities. For these categories, industry statistical data were collected by applying a categorical approach rather than by attempting to identify all the individual firms likely to be affected. The industrial categories studied by this approach included:

- Fixed roof storage tanks
- Solvent metal cleaning
- Gasoline service stations
- Use of cutback asphalt
- Bulk gasoline plants.

For these industrial categories, secondary data sources and nonconfidential Booz, Allen files served as the primary resources for the data base. Industry and association in-terviews were then conducted to complete, refine and validate the industry statistical data base.

For the remaining industrial categories studied, a more deliberate approach was applied to determine those firms potentially affected by the proposed regulations.

- As a first step, the facilities potentially affected by the RACT guidelines were identified from both the Tennessee emission data and secondary data sources.
    - These two independently compiled lists were correlated to identify the facilities potentially affected but not listed as VOC emitters in the Tennessee emission data. Representatives of the State of Tennessee thus identified those facilities potentially affected in each RACT industrial category.

  - The Booz, Allen study team then performed telephone interviews with a sampling of the facilities identified where there was doubt concerning inclusion.

- Industry category statistical data were compiled using secondary sources such as:
  - Department of Commerce
  - Census of Manufacturers
  - Trade associations
  - Bureau of Labor Statistics
  - National Technical Information Services.

- The industry statistical data were refined by two mechanisms:
  - Assessing the statistical data for reasonableness in comparison to the preliminary list of potentially affected facilities
  - Using industry and association interviews for completion and validation.

2.4.2 VOC Emissions

An approach that made maximum utilization of the existing Tennessee emission data was defined.

- State and local air-pollution control agency representatives were interviewed to determine the completeness and validity of emission data available for each RACT industrial category. Emission data was not available at all the potentially affected facilities and the emission inventory had not been completely validated.

- The state and local officials provided emissions data for relevant industrial categories. These RACT industrial categories included:
  - Cans
  - Coils
  - Fabrics
  - Paper
  - Metal furniture
  - Large appliances.

- For the other RACT categories to be studied, the emissions were estimated by applying relevant factors (VOC emissions per facility, throughput, etc.) that had been developed by EPA studies. Although this categorical approach cannot be validated to the degree of a point source by point source approach, the emissions can be reasonably estimated on a statewide basis because of the large number of sources in each RACT industrial category. Emissions were estimated by this approach for the following RACT industrial categories:

    - Bulk gasoline plants
    - Bulk gasoline terminals
    - Refinery systems
    - Solvent metal cleaning
    - Service stations
    - Cutback asphalt
    - Fixed roof tanks.

The emission estimates for each of the 13 RACT industrial categories studied were refined during industry interviews.

2.4.3. Process Descriptions

For each of the industrial categories, the basic technology and emission date were reviewed and summarized concisely for subsequent evaluation of engineering alternatives. In this task, the RACT documents that had been prepared for each industrial category and other air pollution control engineering studies served as the basis for defining technological practice. Additional alternatives of control that met the requirements of the RACT guidelines were identified from literature search. The most likely control alternatives were assessed and evaluated by:

- Technical staff at Booz, Allen
- Interviews with industry representatives
- Interviews with EPA representatives
- Interviews with equipment manufacturers.

2.4.4 Cost of Controlling VOC Emissions

The cost of control to meet the requirements of the RACT guidelines had been presented in the RACT documents, other technical EPA studies and trade journal technical documents and by industry representatives. The approach applied in developing capital and annualized cost estimates was to:

- Utilize available secondary source information as the primary data source
- Validate the control alternatives industry is likely to apply
- Calibrate these cost estimates provided in technical documents.

It was not within the purpose or the scope of this project to provide detailed engineering costs to estimate the cost of compliance.

Cost data presented within the body of the report were standardized in the following manner:

- All cost figures are presented for a base year, 1977.
- Capital cost figures represent installed equipment cost including:
  - Engineering
  - Design
  - Materials
  - Equipment
  - Construction.

  The capital cost estimates do not account for costs such as:

  - Clean-up of equipment
  - Lost sales during equipment downtime
  - Equipment start-up and testing
  - Initial provisions (spare parts).

  Capital related annual costs are estimated at 25 percent of the total capital cost per year (unless explicitly stated otherwise). The estimation procedure applied was built up from the following factors:

  - Depreciation -- straight-line over a ten-year life
  - Interest -- 10 percent
  - Taxes and insurance -- 4 percent
  - Maintenance -- 5 percent.

The capital-related annual costs do not account for investment costs in terms of return or investment parameters (i.e., the "opportunity cost" of money is not included).

- Annual operating costs of compliance with the RACT guidelines were estimated for each of the control alternatives studied. The annual operating costs included were:

  - Direct labor
  - Raw material costs (or savings)
  - Energy
  - Product recovery cost (or savings)
  - Maintenance.

  Other types of costs, not included in this analysis, involve compliance costs, such as:

  - Demonstration of control equipment efficiency

  - Supervisory or management time

  - Cost of labor or downtime during installation and startup.

- The annualized cost is the total of direct operating costs (including product or raw material recovery) and the capital related annual costs.

2.4.5 Comparison of Direct Cost with Selected Direct Economic Indicators

In each of the industrial categories studied, after the costs (or savings) of compliance had been determined, these costs were compared with selected economic indicators. This comparison was performed to gain a perspective on the compliance costs rather than to estimate price changes or other secondary effects of the regulation. Presented below are typical comparisons of direct costs with indicators that are presented in this study.

- Annualized cost in relation to current price—To gain a perspective on the compliance cost in relation to current prices of the manufactured items at the potentially affected facilities, the annualized cost is presented in terms of a price increase assuming a direct pass-through of costs to the marketplace.

  - This analysis was based on the average cost change (including those facilities that may have little or no economic impact associated with meeting the proposed standards) divided by the average unit price of goods manufactured.
  - For this reason as well as many others (that might be addressed in a rigorous input-output study to estimate eventual price increase), this analysis should not be interpreted as forecast of price changes due to the proposed standards.

- Annualized costs as a percent of current value of shipment—The annualized costs applied are for all those facilities potentially affected divided by the estimated value of shipments for the statewide industrial category (i.e., including those facilities which currently may meet the proposed standard). This approach tends to understate the effect to those specific firms requiring additional expenditures to meet the proposed standard. Therefore, when available, the compliance cost is also presented as a percent of the value of shipments for only those firms not currently meeting the proposed regulation.

- Capital investment as a percent of current annual capital appropriations—Estimated statewide capital investment for the potentially affected facilities divided by the estimated capital appropriations for the industry affected as a whole in the state (including those facilities that may not require any capital investment to meet the proposed standard).

2.5 QUALITY OF ESTIMATES

The quality of the estimates that are presented in this report can be judged by evaluating the basis for estimates of the individual study components. In each of the chapters that deal with the development of estimated compliance cost, the sources of information are fully documented. In addition, the study team has categorically ranked the overall data quality of the major sources and, therefore, of the outcomes. These data quality estimates were ranked into three categories:

- High quality ("hard data")—study inputs with variation of not more than ± 25 percent
- Medium quality ("extrapolated data")—study inputs with variation of ± 25 to 75 percent
- Low quality ("rough data")—study inputs with variation of ± 50 to 150 percent.

Each of these data quality estimates is presented in the individual chapters. The overall quality ranking of the study inputs for each RACT industrial category was generally in the medium quality range.

2.6 DEFINITIONS OF TERMS

Listed below are definitions of terms that are used in the body of the report:

- Capture system--the equipment (including hoods, ducts, fans, etc.) used to contain, capture, or transport a pollutant to a control device.
- Coating applicator--an apparatus used to apply a surface coating.
- Coating line--one or more apparatuses or operations which include a coating applicator, flash-off area and oven, wherein a surface coating is applied, dried and/or cured.
- Control device--equipment (incinerator, adsorber or the like) used to destroy or remove air pollutant(s) prior to discharge to the ambient air.
- Continuous vapor control system--a vapor control system that treats vapors displaced from tanks during filling on a demand basis without intermediate accumulation.
- Direct cost pass-through--the relationship of the direct annualized compliance cost (increase or decrease) to meet the RACT limitations in terms of units produced (costs per unit value of manufactured goods.)
- Emission--the release or discharge, whether directly or indirectly, of any air pollutant into the ambient air from any source.
- Facility--any building, structure, installation, activity or combination thereof which contains a stationary source of air contaminants.
- Flashoff area--the space between the application area and the oven.
- Hydrocarbon--any organic compound of carbon and hydrogen only.

- Incinerator--a combustion apparatus designed for high temperature operation in which solid, semisolid, liquid or gaseous combustible wastes are ignited and burned efficiently and from which the solid and gaseous residues contain little or no combustible material.

- Intermittent vapor control system--a vapor control system that employs an intermediate vapor holder to accumulate vapors displaced from tanks during filling. The control device treats the accumulated vapors only during automatically controlled cycles.

- Loading rack--an aggregation or combination of gasoline loading equipment arranged so that all loading outlets in the combination can be connected to a tank truck or trailer parked in a specified loading space.

- Organic material--a chemical compound of carbon excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate.

- Oven--a chamber within which heat is used to bake, cure, polymerize and/or dry a surface coating.

- Prime coat--the first film of coating applied in a two-coat operation.

- Reasonably available control technology (RACT)--the lowest emission limit as defined by EPA that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories.

- Reid vapor pressure--the absolute vapor pressure of volatile crude oil and volatile nonviscous petroleum liquids, except liquified petroleum gases, as determined by American Society for Testing and Materials, Part 17, 1973, D-323-72 (Reapproved 1977).

- Shutdown--the cessation of operation of a facility or emission control equipment.

- Solvent--organic material which is liquid at standard conditions and which is used as a dissolver, viscosity reducer or cleaning agent.

- Standard conditions--a temperature of 20°C (68°F) and pressure of 760 millimeters of mercury (29.92 inches of mercury).

- Startup--the setting in operation of a source or emission control equipment.

- Stationary source--any article, machine, process equipment or other contrivance from which air pollutants emanate or are emitted, either directly or indirectly, from a fixed location.

- Topcoat--the final film of coating applied in a multiple coat operation.

- True vapor pressure--the equilibrium partial pressure exerted by a petroleum liquid as determined in accordance with methods described in American Petroleum Institute Bulletin 2517, "Evaporation Loss from Floating Roof Tanks," 1962.

- Equivalent barrel of oil--energy demand is converted into barrels of oil at the conversion rate of 6,000,000 BTU per barrel of oil.

- Vapor collection system--a vapor transport system which uses direct displacement by the liquid loaded to force vapors from the tank into a vapor control system.

- Vapor control system--a system that prevents release to the atmosphere of at least 90 percent by weight of organic compounds in the vapors displaced from a tank during the transfer of gasoline.

- Volatile organic compound (VOC)--any compound of carbon that has a vapor pressure greater than 0.1 millimeters of mercury at standard conditions excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates and ammonium carbonate.

3.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF TENNESSEE

This chapter presents a preliminary economic analysis of implementing RACT controls for can manufacturing plants in the State of Tennessee. The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of can manufacturing plants, interviews and analysis.

3.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for can manufacturing plants in Tennessee.

The quality of the estimates is described in detail in the latter part of this section.

3.1.1 Industry Statistics

Industry statistics on can manufacturing plants were obtained from several sources. All data were converted to a base year 1977 based on specific scaling factors. The number of establishments for 1977 was based on the 1978 Tennessee Directory of Manufacturers inventory and supplemented by a review of the 1976 County Business Patterns and interviews with selected can manufacturing corporations. The number of employees was obtained from the 1978 Tennessee Directory of Manufacturers.

The number of cans manufactured was based upon scaling up 1972 published data to 1977.

- The 1972 Census of Manufactures reported a total U.S. volume of shipments of 78 billion units with a value of $4.5 billion.
- The value of shipments in Tennessee was reported as $16.9 million.
- The value of shipments for 1976 in the U.S. was reported to be $6,357 million. Based upon the same ratio of state production to total U.S. production as in 1972, the 1976 production in Tennessee was estimated to have been $24 million representing 325 million units.
- For 1977, the U.S. Industrial Outlook, 1977, indicates that the increase in production is 3 percent, with a 10 percent increase in value of shipments. However, based upon the interviews, the 1977 production was estimated to be 600 million cans, and value of shipments at $40 million to $45 million.
- The product mix of the type of cans currently produced in the state was estimated based on the interviews.

3.1.2 VOC Emissions

The data for determining the current level of emissions was estimated by the study team because the Tennessee emissions inventory was unavailable at the time this preliminary assessment was undertaken. Most can manufacturing plants employ similar technology to produce the same product, so that there is a good correlation between can production and coating consumption once the type of can manufactured is known.

3.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for can manufacturing plants are described in Control of Volatile Organic Emissions from Existing Stationary Sources, EPA-450/2-77-008. The data provide the alternatives available for controlling VOC emissions from can manufacturing plants. Several studies of VOC emission control were also analyzed in detail, and the industry trade association and can manufacturers were interviewed to ascertain the most likely types of control techniques to be used in can manufacturing plants in Tennessee. The specific studies analyzed were Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, and informational literature supplied by the Can Manufacturers Institute to the state EPA programs.

The alternative approaches to VOC control as presented in the RACT document were supplemented by several other approaches. The approaches were arrayed and the emissions to be reduced from using each type of control were determined. This scheme forms the basis of the cost analysis, for which the methodology is described in the following paragraphs.

3.1.4 Cost of Control Approaches and the Resulting Reduction in VOCs

The costs of VOC control approaches were developed by:

- Separating the manufacturing process into discrete coating operations:
    - By can manufacturing technology
    - By type of can manufactured; i.e., beer vs. food
- Determining the alternative approaches to control likely to be used for each type of coating operation
- Estimating installed capital costs for each approach
- Estimating the probable use of each approach to control considering:
    - Installed capital cost
    - Annualized cost
    - Incremental costs for materials and energy
    - Technical feasibility by 1981

  (This estimate was based on discussions with knowledgable individuals in the can manufacturing industry.)

- Aggregating costs to the total industry in Tennessee.

Costs were determined from analysis of the previously mentioned studies:

- Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-008
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories

and from informational data supplied by the Can Manufacturers Institute and from interviews with major can manufacturing companies.

The cost of compliance and the expected emission reduction in Tennessee were developed based on plant operational data included in the Tennessee emission inventory and refined during interviews with can manufacturers. Based upon the assessment of the degree and types of controls currently in place, the cost of VOC emission control and the net reduction in emissions were estimated.

3.1.5 Economic Impact

The economic impact was analyzed by considering the lead time requirements needed to implement RACT, assessing the feasibility of instituting RACT controls in terms of available technology, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary impacts on market structure, employment and productivity from implementing RACT controls in Tennessee.

3.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on can manufacturing plants in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, "B" indicates data were extrapolated from hard data and "C" indicates data were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 3-1, on the following page, rates each study output and overall quality of the data. It should be noted that the findings are preliminary estimates because the estimates of costs of control are only as good as the assessment of the 1977 baseline, particularly the degree of usage of "exempt" solvents and the percentage of solvent that is actually incinerated.

EXHIBIT 3-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	X
Emissions			X
Cost of emissions control			X
Statewide costs of emissions			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

3.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for can manufacturing plants in Tennessee are presented in this section. The source of industry statistics was the Tennessee Directory of Manufacturers, The Can Manufacturers' Institute and the individual can manufacturing companies. Data in this section form the basis for assessing the impact of implementing RACT to VOC emissions from can manufacturing plants in the state.

3.2.1 Size of the Industry

The can manufacturing industry in Tennessee is small when compared to the industry in the midwestern states. There are six or seven can manufacturing facilities in the state; all but one is relatively small by industry standards. These plants primarily assemble food and beverage cans from precoated stock shipped to the plants from facilities in other states. Exhibit 3-2, on the following page, presents a list of seven can facilities in the state that have been identified. The American Can Company plant in Memphis will be closed during 1978 and the Boise Cascade plant in Jackson is probably incorrectly included in SIC 3411. The industry shipped 32.5 million cans with an estimated value of $24 million in 1977, while employing 400 to 500 people. Can industry capital investments are estimated to have been $2 million to $6 million in 1977, based upon an extrapolation of 1972 data.

3.2.2 Comparison of the Industry to the State Economy

The Tennessee can manufacturing industry employs 0.1 percent of the state labor force, excluding government employees. The state appears to be a net importer of cans, both in the form of coated stock and fabricated.

3.2.3 Characterization of the Industry

The can industry is composed of independent and captive manufacturers. Nationwide, about 70 percent of all cans are produced by independent manufacturers and about 30 percent by captive producers. The majority of captive can producers use the cans to package canned food/soup and beer. Of the seven can manufacturing facilities identified in Tennessee, six are independent and one is captive. There are no fully integrated can manufacturing plants in the state. All plants form cans from stock and ends coated in other states.

The independent can producers generally operate on a "job shop" basis, producing cans for several customers on the same production facilities. In addition to differences in can size and shape, there are differences in coatings resulting from:

EXHIBIT 3-2
U.S. Environmental Protection Agency
LIST OF METAL CAN MANUFACTURING FACILITIES
POTENTIALLY AFFECTED BY RACT IN TENNESSEE

Name Of Firm	Location	Product	Notes
American Can Company	Chattanooga	3-piece soft drink cans	Can assembly only Uses solvent coatings Exempt under Rule 66
American Can Company	Memphis	3-piece beverage cans	Can assembly only Plant being closed in 1978
National Can Company	Collierville	3-piece beer and soft drink cans 3-piece food cans	Can assembly only
Diamond International	Dandridge	Not available	Can assembly only
Stokley Van Camp	Newport	3-piece food cans	Can assembly only Captive use only Little or no coating
Ring Can Company	Oakland	Lard cans	Not available
Boise Cascade	Jackson	Composite cans (oil?)	Probably not included in RACT under can coating

Source: Booz, Allen & Hamilton Inc.

- The need to protect different products with varying characteristics from deterioration through contact with the metal can

- The decoration requirements of customers and requirements for protection of the decoration.

Nationally, the can industry produces more than 600 different shapes styles and sizes to package more than 2,500 products. A relatively few can sizes and coating combinations employed for packaging beverages and food represent about 80 percent of the market. The approximate percentage of total can production represented by the major groups follows:

Type of Can	Percent of Total Production
Beer and soft drink	54
Fruit and vegetable	18
Food cans in the category that includes soup cans	8
Other	20
TOTAL	100

In Tennessee, the small can industry is focused on meeting the needs of the beverage and vegetable canning industries in the state. Of the 32.5 million cans produced in Tennessee in 1977, approximately 200 million (61 percent) are estimated to have been beer and soft drink cans, and 125 million (39 percent) were food cans.

Nationally, the can industry has experienced rapid technological changes since 1970 caused by the introduction of new can making technology--the two-piece can. These changes in can manufacturing technology have resulted in the closing of many can plants producing the traditional three-piece product and replacing capacity with two-piece cans. There is evidence that this trend will continue, so that by 1981 about 80 percent of the beverage cans and a relatively small but growing percentage of other cans will be of two-piece construction. However, to date, no two-piece beverage can plants have been constructed in Tennessee.

3.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on can manufacturing operation, estimated VOC emissions, the extent of current emission control and the likely alternatives which may be used for controlling VOC emissions in Tennessee.

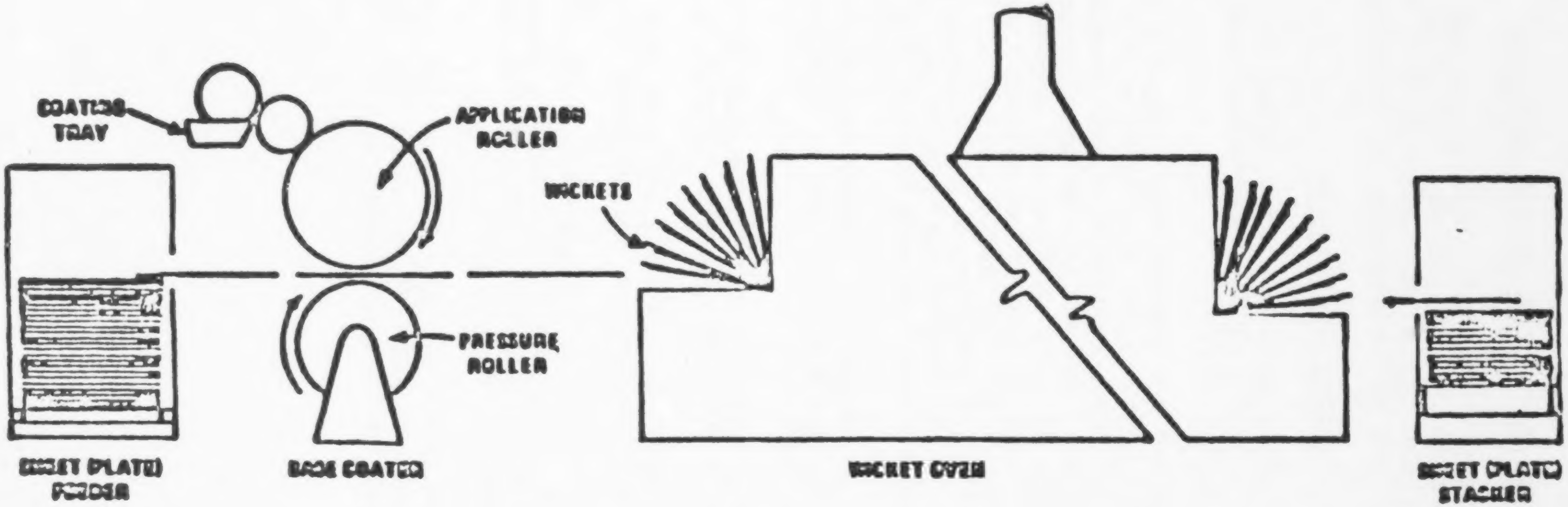
3.3.1 Can Manufacturing Operations

The can industry produces cans using two fundamental technologies, the traditional three-piece method and the newer two-piece technology.

The three-piece can technology consists of two separate operations: sheet coating and can fabrication (assembly). Sheet coating and can assembly operations are frequently performed in separate facilities. The major can manufacturers operate centralized facilties for the coating and decorating of flat sheets. These centralized plants are often called "feeder plants." (There were no feeder plants in Tennessee during 1977.) Sheets are coated at a rate of about 2.5 base boxes per minute, which is equivalent to approximately 1,250 twelve-ounce cans per minute. The specific operations in three-piece can manufacture are summarized below.

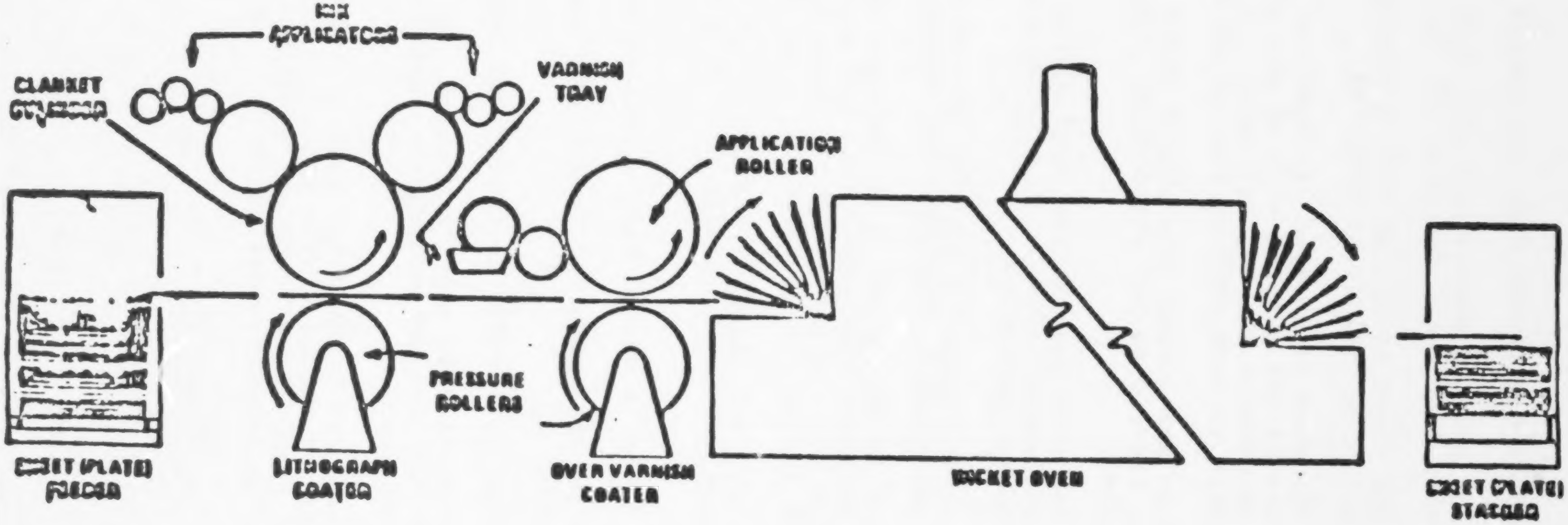
- Sheets of metal are coated and decorated with 28 or 35 can bodies (outs). This is accomplished in two steps.
  - The sheets are base coated on the interior side and then passed through a wicket oven.
  - Food cans, as well as some beer and soft drink cans, are given an exterior base coat.
  - In the case of beer and soft drink cans, the base coated sheets are decorated (printed), over coated with varnish and then cured in a smaller wicket oven.
  - Exhibits 3-3 and 3-4, on the following pages, present flow diagrams of the base coating and decorating operations.

EXHIBIT 3-3
U.S. Environmental Protection Agency
SHEET BASE COATING OPERATION


COATING TRAY
APPLICATION ROLLER
WICKETS
PRESSURE ROLLER
SHEET (PLATE) FEEDER
BASE COATER
WICKET OVEN
SHEET (PLATE) STACKER

Source: U.S. Environmental Protection Agency

EXHIBIT 3-4
U.S. Environmental Protection Agency
SHEET PRINTING OPERATION


INK APPLICATORS
BLANKET CYLINDER
VARNISH TRAY
APPLICATION ROLLER
PRESSURE ROLLERS
SHEET (PLATE) FEEDER
LITHOGRAPH COATER
OVER VARNISH COATER
WICKET OVEN
SHEET (PLATE) STACKER

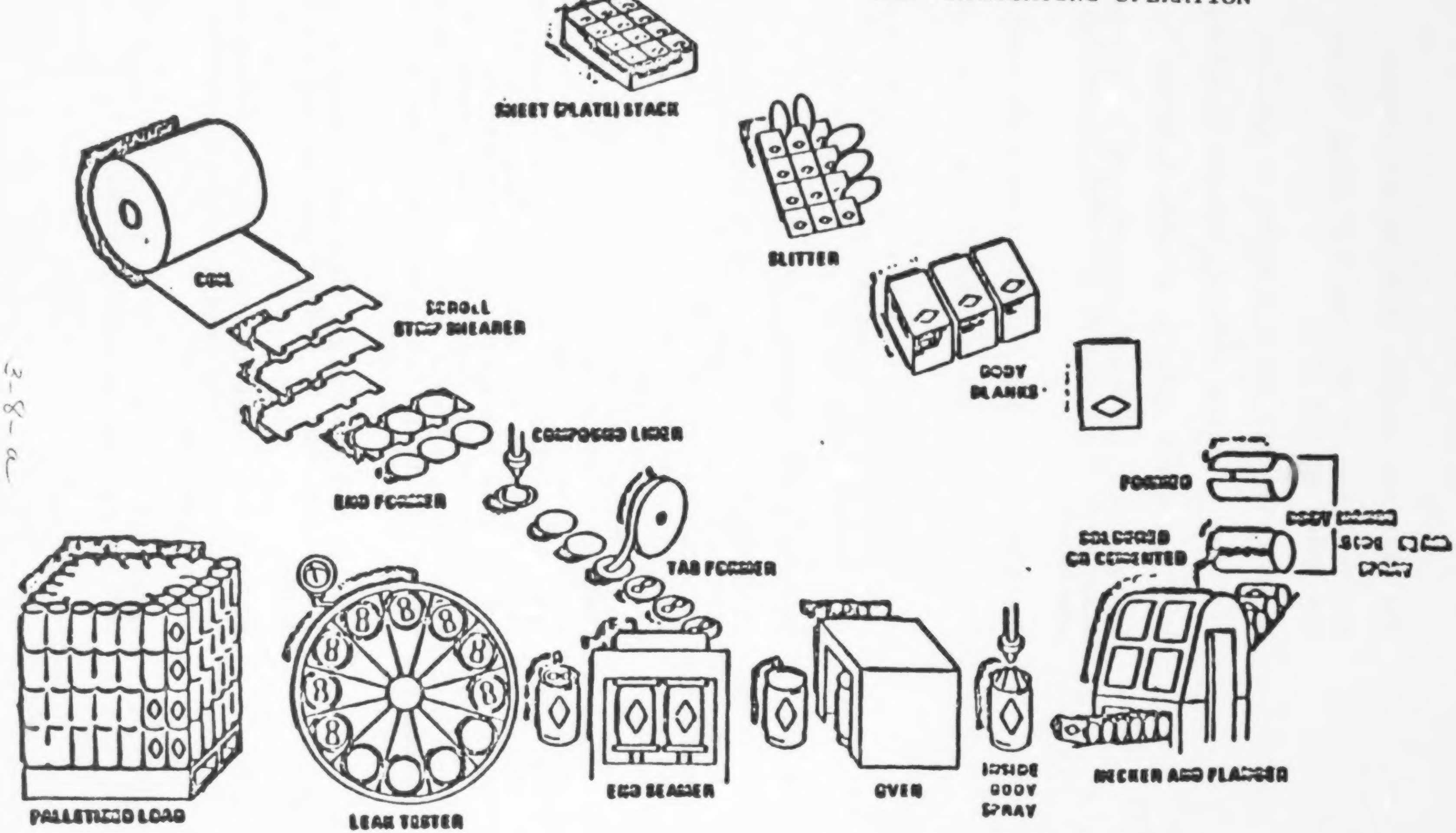
Source: U.S. Environmental Protection Agency

- Can bodies are formed from the coated sheets.
    - The printed sheets are slit into individual body blanks and fed into the "body maker."
    - The blank is rolled into a cylinder and soldered, welded or cemented.
    - The seam is sprayed (striped) on the inside and outside with an air dry lacquer to protect the exposed metal. Sometimes this is done only on the inside surfaces.
- Can ends are formed from coated sheet stock and fed to the end seamer where final fabrication is completed.
    - Can ends are stamped from coated stock and perimeter coated with synthetic rubber compound gasketing.
    - Solvent-based compounds are air-dried and water-based compounds are oven-dried.
- The can is fabricated from the body and the end in an "end sealer," leak tested and palletized for shipment. Exhibit 3-5, on the following page, presents a schematic of can end and three-piece can fabricating operations.

Two-piece cans are generally manufactured in an integrated high-speed process capable of producing 600 or 800 cans per minute.

- Coil stock is formed into a shallow cup.
- The cups are drawn and ironed into the form of a can.
- The cans are washed to remove the lubricant.
- An exterior base coat is applied (if required) by reverse roller coating and cured in a continuous oven.
- The cans are printed and then coated with a protective varnish. The coating is then baked in an oven. Steel cans are sometimes given two separate interior coatings.

EXHIBIT 3-5
U.S. Environmental Protection Agency
CAN END, AND THREE-PIECE BEER AND BEVERAGE
CAN FABRICATING OPERATION


SHEET (PLATE) STACK
COIL
SLITTER
SCROLL
STRIP SHEARER
BODY
BLANKS
COMPOUND LINER
END FORMER
FORMED
BODY MAKER
SOLDERED
OR CEMENTED
SIDE SEAM
SPRAY
TAB FORMER
PALLETIZED LOAD
LEAK TESTER
END SEAMER
OVEN
INSIDE
BODY
SPRAY
NECKER AND FLANGER

Source: U.S. Environmental Protection Agency

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- The cans are necked, flanged and tested.

- The interior of the cans are spray coated and baked in the oven.

- An exterior end spray coating is applied:

  - For aluminum cans to prevent blocking

  - For steel cans to prevent rusting.

- Exhibit 3-6, on the following page, is a process diagram of a two-piece can fabricating and coating operation.

- Two-piece cans are largely made from aluminum.

  - Virtually all aluminum cans are of two-piece construction.

  - Aluminum lends itself to two-piece construction, yet offers no advantage to warrant converting three-piece can lines to aluminum.

3.3.2 Emissions and Current Controls

The can industry is moving toward products with inherently lower VOC emissions during manufacture. Differences in the manufacturing process between two-piece and three-piece cans allow for a 50 percent to 60 percent reduction in emissions in converting from a three-piece beer can to a two-piece beer can decorated in a similar manner. This is caused by a greater number of interior coating operations for three-piece cans, as well as a tendency to eliminate certain exterior coatings on two-piece beer and soft drink cans. The exhibits, on the following pages, present the emissions from typical can coating operations based upon average coating properties, can production rates and annual hours of operation. They present data for conventional systems, as well as for low solvent systems. It is important to note that, in most instances, can manufacturing does not require all the coatings.

- Exhibit 3-7 presents VOCs resulting from coating operations used in the manufacture of two-piece cans.

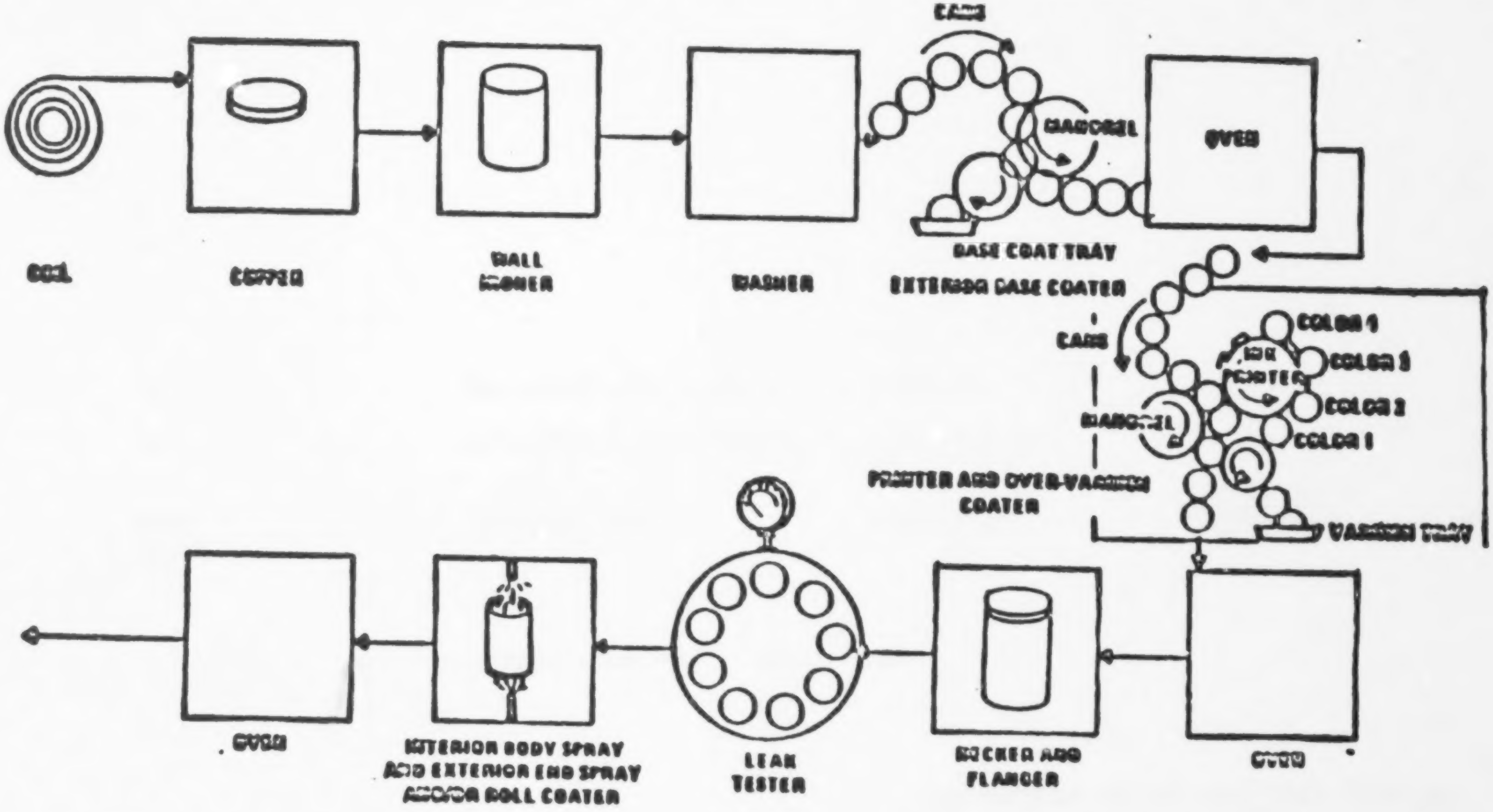
- Exhibit 3-8 presents VOCs resulting from sheet coating operations used in the manufacture of three-piece cans.

- Exhibit 3-9 presents VOCs resulting from typical three-piece can assembly operations.

EXHIBIT 3-6

U.S. Environmental Protection Agency

TWO-PIECE ALUMINUM CAN FABRICATING AND COATING OPERATION


CANS
COIL
CUPPER
WALL IRONER
WASHER
MANDREL
OVEN
BASE COAT TRAY
EXTERIOR BASE COATER
CANS
COLOR 4
INK PRINTER
COLOR 3
COLOR 2
MANDREL
COLOR 1
PRINTER AND OVER-VARNISH COATER
VARNISH TRAY
OVEN
NECKER AND FLANGER
LEAK TESTER
INTERIOR BODY SPRAY AND EXTERIOR END SPRAY AND/OR ROLL COATER
OVEN

Source: U.S. Environmental Protection Agency

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EXHIBIT 3-7
U.S. Environmental Protection Agency
TENNESSEE EMISSIONS--CAN COATING

RACT Category - Metal Cans

SIC CODE	COMPANY NAME	LOCATION	EMISSIONS (tons/yr.)
3411	American Can Company	Chattanooga	145
3411	American Can Company	Memphis	455

Source: Verbal information from state of Tennessee

EXHIBIT 3-8 (1)
U.S. Environmental Protection Agency
EMISSIONS FOR TYPICAL COATING OPERATION USED IN THE MANUFACTURE OF TWO-PIECE CANS

Operation	Coating Properties							
	Density (lb./gal.)	Solids (wt. %)	Organic Solvent (wt. %)	Organic Solvent (lb./gal.)	Water (gal./gal. coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. incl. water)	Yield (1000 can/ gal.)
Organic Systems								
Print and varnish	8.0	45	100	4.40	0	4.40	4.40	12
Size and print	8.0	40	100	4.80	0	4.80	4.80	20
White base coat and print	11.0	62.5	100	4.13	0	4.13	4.13	9
Interior body spray	7.9	26	100	5.85	0	5.85	5.85	6[a]
End coating Al	8.0	45	100	4.40	0	4.40	4.40	200
End coating steel	8.0	45	100	4.40	0	4.40	4.40	40
Low Solvent Systems								
Waterborne								
Print and varnish	8.5	35	20	1.11	0.53	2.36	1.11	11
Size and print	8.5	30	20	1.19	0.57	2.76	1.19	17
White base coat and print	11.7	62	20	0.89	0.43	1.55	0.88	8
Interior body spray	8.55	20	20	1.37	0.66	3.99	1.36	5[a]
End coating Al	8.5	35	20	1.11	0.53	2.36	1.11	200
End coating steel	8.5	35	20	1.11	0.53	2.36	1.11	40
UV Cure High Solids								
Print and varnish[b]	8.0	95	100	0.40	0	0.40	0.40	25

3-9-C

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a. Assuming 75 percent beer cans, all given a single coat, and 25 percent soft drink cans, given a double coating

b. Booz, Allen & Hamilton, Inc. estimate based on data supplied by CMI, individual can manufacturers and the EPA document 450/2-77-008

EXHIBIT 3-8 (2)
U.S. Environmental Protection Agency

Operation	Production		Coating Consumed		VOC		
	(cans/min.)	(Million cans/yr.)	(gal./hr.)	(1000 gal./yr.)	(lb./hr.)	(tons/yr.)	(lb./million cans)
Organic Systems							
Print and varnish	650	253.5	3.25	21.1	14.3	46.5	364
Size and print	650	253.5	1.95	12.7	9.4	30.6	241
White base coat and print	650	253.5	4.33	28.1	17.8	57.9	457
Interior body spray	650	253.5	6.50	42.3	38.0	123.5	974
End coating Al	650	253.5	0.20	1.3	0.9	2.9	23
End coating steel	650	253.5	0.98	6.4	4.3	14.0	110
Low Solvent Systems							
Waterborne							
Print and varnish	650	253.5	3.55	23.1	3.9	12.7	100
Size and print	650	253.5	2.29	14.9	2.7	8.8	69
White base coat and print	650	253.5	4.88	31.7	4.3	14.0	110
Interior body spray	650	253.5	7.80	50.7	10.6	34.5	272
End coating Al	650	253.5	0.20	1.3	0.2	0.7	6
End coating steel	650	253.5	0.98	6.4	1.1	3.6	28
UV Cured High solids							
Print and varnish	650	253.5	1.56	10.1	0.6	2.0	15

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by Can Manufacturers Institute and interviews with can companies.

EXHIBIT 3-9 (1)
U.S. Environmental Protection Agency
COATING AND PRINTING OPERATIONS USED IN
THE MANUFACTURE OF THREE PIECE CANS
(Sheet Coating Operation)

Operation	Coating Properties							Dry Coating Thickness	
	Density (lb./gal.)	Solids (wt %)	Organic Solvent (wt %)	Organic Solvent (lb./gal.)	Water (gal/gal coating)	VOC (lb. solvent/ gal. less water)	VOC (lb. solvent/ gal. including water)	(Mg / 4In2)	(lb. / basebox)
Conventional Organics Systems									
Sizing and print	8.0	40	100	4.80	0	4.80	4.80	5	0.086
Inside basecoat	8.05	40	100	4.83	0	4.83	4.83	20	0.346
Outside white and print	11.0	62.5	100	4.13	0	4.13	4.13	40	0.692
Outside sheet printing and varnish	8.0	45	100	4.40	0	4.40	4.40	10	0.172
Low Solvent Systems									
Sizing (waterborne)	8.5	30	20	1.19	0.57	2.76	1.19	5	0.086
Inside basecoat									
High solids	8.0	80	100	1.60	0	1.60	1.60	20	0.346
Waterborne	8.8	40	20	1.06	0.51	2.15	1.05	20	0.346
Outside white									
High solids	12.0	80	100	2.40	0	2.40	2.40	40	0.692
Waterborne	11.7	62	20	0.89	0.43	1.55	0.88	40	0.692
Outside sheet print and varnish (waterborne)	8.5	35	20	1.11	0.53	2.36	1.11	10	0.172

3-9-e

EXHIBIT 3-9 (2)
U.S. Environmental Protection Agency

Operation	Production		Coating Consumption			VOC		
	(base box hr.)	(1000 base boxes[a] year)	(gallon basebox)	(gallon hour)	(1000 gal. year)	(lb. hour)	(tons year)	(lbs. 1000 base boxes)
Conventional Organics Systems								
Sizing and print	150	240	.027	4.1	6.6	19.7	15.8	130
Inside basecoat	150	240	.107	16.1	25.7	77.8	62.2	517
Outside white and print	150	240	.100	15.0	24.0	62.0	49.6	413
Outside sheet printing and varnish	150	240	.048	7.2	11.5	31.7		211
Low Solvent Systems								
Sizing (waterborne)	150	240	.034	5.1	8.1	6.1	4.9	41
Inside basecoat								
High solids	150	240	.054	8.1	13.0	13.0	10.4	87
Waterborne	150	240	.098	14.7	23.5	15.4	12.3	103
Outside white								
High solids	150	240	.072	10.8	17.3	25.9	20.7	172
Waterborne	150	240	.095	14.3	22.9	12.6	10.1	841
Outside sheet print and varnish (waterborne)	150	240	.057	8.6	13.8	9.5	7.6	63

3-9.e

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[a] Assuming 1,600 hours per year of operation.

Source: Booz, Allen & Hamilton Inc. estimates based on data supplied by Can Manufacturers Institute and interviews with can companies.

The emissions from the industry, developed through the analysis of typical coating operations and the assumed product mix, total an uncontrolled level of 717 tons. Emissions from producing typical products are included in Exhibits 3-12 and 3-13 under the 1978 base case alternatives.

Can Type	Quantity (million)	VOC (tons/million)	Total VOC (tons)
3-piece beer and soft drink assembly with body spray	250	1.061	265
3-piece beer and soft drink	250	1.79	448
3-piece food assembly	100	0.044	4
TOTAL	600		717

The following assumptions were made:

- 250 million beverage cans were produced from precoated and decorated stock. The emission sources were:
  - Inside stripe--88 pounds per million cans
  - Outside stripe--138 pounds per million cans
  - Inside spray--1,463 pounds per million cans
  - End compounding--433 pounds per million cans.
- 250 million beverage cans were produced by first coating sheet stock:
  - Inside base coat--1,034 pounds per million cans
  - Outside print and varnish--412 pounds per million cans
  - Inside stripe--88 pounds per million cans
  - Outside stripe--138 pounds per million cans
  - Inside spray--1,463 pounds per million cans
  - End compounding--433 pounds per million cans.
- All food cans were produced from precoated stock and precompounded ends. The only emission source was the inside stripe--88 pounds per million cans.

The data developed during the interviews indicate that the industry is generally not incinerating emissions at plants in Tennessee. However, the industry may be using waterborne and also exempt solvents as defined by Rule 66; use of exempt solvents is not an acceptable approach under RACT.

3.3.3 RACT Guidelines

The RACT Guidelines for VOC emission control are specified as the amount of allowable VOC, in pounds per gallon of coating, minus any water in the solvent system. To achieve this guideline, RACT suggests the following options:

- Low solvent coatings
    - Waterborne
    - High solids
    - Powder coating
    - Ultraviolet curing of high solids coatings
- Incineration
- Carbon adsorption.

The RACT guidelines have established different limitations for each of four groups of can coating operations. Exhibit 3-10, on the following page presents the recommended VOC limitations, compared with typical, currently available, conventional coatings.

3.3.4 Selection of the Most Likely RACT Alternatives

Projecting the most likely industry response for control of VOC emissions in can manufacturing facilities is complicated by the thousands of different products offered by the can industry. Based on industry interviews, several general assumptions can be made regarding the industry in Tennessee as well as nationally.

- The industry preferred response will be to use low solvent coatings (primarily waterborne) wherever technically feasible because of their low cost--see incremental cost comparisons on Exhibits 3-12 and 3-13.
    - The choice between thermal incinerators and catalytic incinerators will be based on the availability of fuel and the preference of the individual companies.
    - Incinerators with primary heat recovery will be used in preference to those with secondary recovery or no heat recovery.

EXHIBIT 3-10
U.S. Environmental Protection Agency
RACT GUIDELINES FOR CAN COATING OPERATIONS

Coating Operation	Recommended Limitation		Typical Currently Available Conventional Coatings
	kg. per liter of coating (minus water)	lbs. per gallon of coating (minus water)	lbs. per gallon of coating (minus water)
Sheet basecoat (exterior) and interior) and overvarnish; two-piece can exterior (basecoat and overvarnish)	0.34	2.8	4.1-5.5
Two- and three-piece can interior body spray, two-piece can exterior end (spray or roll coat)	0.51	4.2	6.0
Three-piece can side-seam spray	0.66	5.5	7.0
End sealing compound	0.44	3.7	4.3

Source: U.S. Environmental Protection Agency

- The industry will not install carbon adsorption systems because of the very poor performance record established to date in several can plants that have evaluated this control approach.

- Six likely control alternatives, as well as two base cases, are discussed in the paragraphs below. The percentage of cans likely to be manufactured by each of the control option alternatives, by 1982, is summarized in Exhibit 3-11, on the following page. The resulting emissions are summarized in Exhibits 3-12 and 3-13, at the end of this section. For cases involving incineration, the following assumptions were made.

    - Energy cost is \$2.25 per million BTUs.

    - Capital cost is \$20,000 per 1000 CFM.

    - Incinerators operate at 10 percent of the lower explosive limit.

    - 90 percent of the roller coating emissions are collected and incinerated.

    - 30 percent of the interior spray coating emissions are collected and incinerated.

The assumptions on cost operating parameters and likely industry response to each control alternative were based upon discussions with knowledgeable industry sources and on Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

3.3.4.1 Three-Piece Beer and Soft Drink Cans--Base Case

At the present time, the majority of three-piece beer and soft drink cans are produced by the following coating operations:

- Interior base coat
- Decoration and over varnish
- Interior and exterior stripe
- Interior spray coating
- End sealant.

The production of beer cans differs from the production of soft drink cans in some respects that have not been considered in this study.

- Beer cans almost always have an exterior stripe, but soft drink cans frequently do not.

EXHIBIT 3-11
U.S. Environmental Protection Agency
ESTIMATED PERCENTAGE OF CANS
TO BE MANUFACTURED IN 1982
USING EACH VOC CONTROL ALTERNATIVE

Type Of Can Manufactured	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Print Only, All Low Solvent Coatings	Low Solvent Coatings Except End Sealant Which is Incinerated	UV Cured Outside Varnish Waterborne Inside Spray
2-piece beer and soft drink	--	--	--	--	--
3-piece beer and soft drink	70	10	--	20	--
3-piece food and other cans	50	50	--	0	--

Source: Booz, Allen & Hamilton Inc.

- Beer cans always have an inside spray coating but soft drink cans usually do not. However, soft drink cans frequently have a heavier inside base coat to offset the elimination of the spray coating.

Consideration of these differences has been eliminated to reduce the complexity of the study. Because of the declining importance of three-piece beer and beverage cans, the impact will be smaller in 1982 than it would be currently.

The total emissions from this alternative are 1.79 tons per million cans (2.5 times the emissions from a similar two-piece can).

3.3.4.2 Three-Piece Beer and Soft Drink Cans--Waterborne Coatings as proposed by RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings. The cost of converting to waterborne systems was assumed to be minimal.

- The capital cost for converting each of five coating operations was assumed to be $10,000. This results in an annualized capital cost of $104 per million cans--assuming that the cost of capital and maintenance is 25 percent of the total installed capital cost and that 120 million cans are produced annually on the coating line.

- The raw material cost of coatings is the same as for conventional coatings.

- The energy consumption is the same--this would appear reasonable since most of the energy is consumed to heat the wickets and belts and also the metal.

- The yield (spoilage) is the same--it appears that the industry will continue to encounter significant spoilage in changing over to new coatings. However, as the technology is established, it is assumed that spoilage will decline to currently acceptable levels.

The total incremental cost to convert to waterborne coatings is estimated to be about $100 per million cans. This represents a cost increase of about 0.15 percent. The emissions would be reduced to 0.34 tons per million cans, an 80 percent reduction at a cost of about $72 per ton.

It is estimated that 70 percent of all beer and soft drink facilities will employ this option. The acceptance of this technology will be retarded by the lack of a complete line of available coatings.

3.3.4.3 Three-Piece Beer and Soft Drink Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators. Thermal incinerators are widely employed in the middle west but no thermal incinerators have been identified in Tennessee.

The capital required for five incinerators would be about $320,000--assuming an installed cost of $20,000 per 1,000 CFM.

- The annualized capital cost would be about $668 per million cans.
- The energy cost to operate the incinerators would be $166 per million cans.
- The material cost would be the same as the base case.

The total incremental cost of adopting thermal incineration is estimated to be about $834 per million cans. This represents a cost increase of about 0.2 percent. The emissions would be reduced by 59 percent to 0.74 tons per million cans at a cost of $794 per ton of emissions removed. Because of the prohibitively high costs of this alternative, it is estimated that it will be employed only on 10 percent of all three-piece beer and soft drink cans manufactured in Tennessee in 1982.

3.3.4.4 Three-Piece Beer and Soft Drink Cans--All Waterborne Except End Sealant, which is Thermally Incinerated

It is likely that the can industry will adopt a hybrid system which will focus on waterborne or possibly other low solvent coatings and thermal incineration of the end sealant and which probably will not be universally available by 1982. Because end sealing compounds represent approximately 12 percent of the VOC from three-piece beer and soft drink can manufacture, this case was developed under the assumption that technology-based exceptions will not be granted.

- The capital cost of converting four coating operations and adding one incinerator would be about $340 per million cans.
- The additional energy costs of one incinerator would be about $93 per million cans.

- Material cost would be the same

The total incremental cost of this scenario would be about $171 per million cans. This represents a cost increase of about 0.2 percent, to reduce emissions by 80 percent. It is estimated that about 20 percent of the beer and soft drink cans will be produced using this technology. (This does not include cans that are precoated with noncomplying coatings in other states.)

3.3.4.5 Three-Piece Food Cans--Base Case

Three-piece food cans are currently produced utilizing the following coating operations:

- Interior base coat
- Exterior base coat
- Interior stripe
- End sealant.

The emissions from this case are estimated to be 0.99 tons per million cans.

3.3.4.6 Three-Piece Food Cans--Waterborne as Proposed in RACT

In this alternative, all the coating operations currently employed in the base case have been converted to waterborne coatings.

The total incremental cost to convert to waterborne coatings is estimated to be $113 per million cans. A 76 percent reduction in emissions is achieved, to 0.24 tons per million cans. It is unlikely that a complete spectrum of waterborne coatings will be available to meet industry requirements by 1982 because:

- The focus of research is on two-piece beer and soft drink cans, which is the most rapidly growing market segment.

- The need to achieve FDA approval for the broad spectrum of products needed to meet diverse requirements has also caused coating manufacturers to focus on the large-volume coatings required for beer and soft drinks.

As a result, it is estimated that only 50 percent of the cans will be produced using this control approach. (This category includes noncomplying coatings that are applied in feeder plants located in other states.)

3.3.4.7 Three-Piece Food Cans--Base Case with Thermal Incinerators and Primary Heat Recovery

This alternative assumes that all coating operations currently employed in the base case are retrofitted with thermal incinerators.

The total incremental cost of adopting this approach is estimated to be about $690 per million cans, $595 in capital cost and $95 in energy costs. Emissions would be reduced by 81 percent, to 0.19 tons per million cans. An estimated 50 percent of the cans would be produced using this approach.

3.3.4.8 Three-Piece Food Cans--All Waterborne Except End Sealant, Which Is Thermally Incinerated

Because waterborne and other low solvent coatings are not available, it is likely that the industry will develop a hybrid approach utilizing waterborne coatings where available and incinerating the balance. The end sealing compound appears to be the coating most likely to be unavailable in low solvent form by 1982--end sealing compounds released about 18 percent of the VOC emissions from food can manufacturing operations.

The total incremental cost of this scenario is about $210 per million cans; $100 in capital cost and $20 in energy costs. The emissions are reduced by about 79 percent to 0.25 tons per million cans. It is estimated that no cans would be produced using this approach; cans would be precoated with noncomplying coatings in other states.

EXHIBIT 3-12
U.S. Environmental Protection Agency
EMISSIONS FROM COATING TWO-PIECE ALUMINUM
BEER AND SOFT DRINK CANS PER MILLION CANS

Alternative	Capital ($)	Annualized Incremental Costs: Annualized Capital Cost ($)	Materials ($)	Energy ($)	Total ($)	Coating Input (gal.)	Emissions: VOC Emissions (tons)	VOC Decrease (tons)	%	Incremental Cost (per ton)
1978 BASE CASE Print and varnish Nonconfirming interior body spray (exempt solvents) End coating	0	0	0	0	0	250	0.67	a	a	a
WATERBORNE AS PROPOSED IN RACT	120	30	0	0	30	340	0.19	0.48	75	63
BASE CASE WITH THERMAL INCINERATORS & PRIMARY HEAT RECOVERY	266	66	0	62	128	250	0.39	0.29	42	441
SUPPLEMENTAL SCENARIO 1 Print only Waterborne interior body spray End coating using a low varnish solvent	80	20	(540)	(230)	(750)	200	0.14	0.53	79	(1,415)
SUPPLEMENTAL SCENARIO 2 Print UV cured varnish Waterborne interior body spray End coating using a low solvent varnish	120	30	810	105	734	240	0.15	0.52	78	1,411

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a. Not applicable

Source: Booz, Allen & Hamilton Inc. estimates

EXHIBIT 3-13
U.S. Environmental Protection Agency
EMISSIONS FROM COATING THREE-PIECE CANS PER MILLION CANS

Case	Annualized Incremental Costs					Coating And Emissions				
	Capital ($)	Annualized Capital Cost/Millions ($)	Materials ($)	Energy ($)	Total ($)	Coating Input (gal.)	VOC Emissions (tons)	VOC Decrease (tons)	VOC Decrease %	Incremental Cost ($ per ton)
BEVERAGE CANS										
1978 BASE CASE Interior base coat Decoration and/or varnish Interioring and exterior stripe Interior spray End sealant	0	0	0	0	0	894	1.79	a	a	a
WATERBORNE AS PROPOSED IN RACT	416	104	0	0	104	720	0.34	1.45	81	72
BASE CASE WITH THERMAL INCINERATORS AND HEAT RECOVERY PRIMARY	2,670	668	0	166	834	694	0.74	1.05	59	794
SUPPLEMENTAL SCENARIO 3 Waterborne except end sealant which is incinerated	686	171	0	20	191	715	0.35	1.44	80	133
FOOD CANS										
1978 BASE COAT Interior base coat Exterior base coat Interior stripe End sealant	0	0	0	0	0	424	0.99	a	a	a
WATERBORNE AS PROPOSED IN RACT	453	113	0	95	687	439	0.24	0.75	76	151
BASE CASE WITH THERMAL INCINERATORS AND PRIMARY HEAT RECOVERY	2,380	595	0	95	687	424	0.19	0.80	81	859
SUPPLEMENTAL SCENARIO 4 All waterborne except end sealant which is incinerated	768	192	0	17	209	435	0.23	0.76	77	275

---

a. Not applicable.

Source: Booz, Allen & Hamilton Inc. estimates.

3.4 COST AND VOC BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for alternative VOC emission controls are presented in this section, based upon the costs per million cans developed for each alternative in the previous section. The extrapolation is based upon can production and emissions for actual can manufacturing processes and not upon the representative plants.

3.4.1 Costs for Alternative Control Systems

Although there is no typical can manufacturing facility, the following representative plants describe the situation in most can manufacturing facilities.

- Representative Plant A produces 80 percent three-piece beer and soft drink cans and 20 percent three-piece food cans using three assembly lines. Each can assembly line operates at 400 cans per minute, the beer lines for 5,000 hours annually and the food can lines for 3,000 hours annually.
- Representative Plant B produces food cans from precoated stock. It contains one can assembly line which operates at 400 cans per minute for 3,000 hours annually. The total plant production is 72 million cans.

The capital cost to adopt the alternative controls to the two representative plants ranges from $10,000 (to convert the one-line assembly plant to waterborne coatings) to $160,000 (to retrofit the three-line assembly plant with incinerators). The incremental operating costs (energy plus 25 percent of capital) range from $5,000 for operating the small food can assembly plant with waterborne coatings to about $150,000 for operating incinerators at the larger three-piece assembly plant. Capital and annual operating costs for each of the representative plants is presented for each applicable alternative on Exhibit 3-14, on the following page.

3.4.2 Extrapolation of the Costs to the Statewide Industry

The costs developed are incremental costs based on the production volume and mix estimate for 1977. Industry changes related to plant closing, conversion to two-piece lines, consumption patterns or other areas not directly related to RACT implementation were not included. One exception is that the trend to print-only on existing lines was addressed and the portion allocated to RACT was estimated and included in the final figures.

EXHIBIT 3-14
U.S. Environmental Protection Agency
COST OF IMPLEMENTING RACT ALTERNATIVES FOR
REPRESENTATIVE CAN MANUFACTURING PLANTS ($1,000)

Representative Plant	Waterborne		Thermal Incinerators		Print Only/Waterborne		UV Cured/Waterborne		Waterborne Incinerated End Sealant	
	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense	Capital	Annual Expense
A. 3-piece beer & soft drink and food can	80	20	160	150	a	a	b	b	82	42
B. Food can assembly plant 2 assembly lines with inside striping 72 million cans	10	3	30	10	a	a	b	b	a	a

---

a. Not applicable
b. Not considered to be a likely response by 1982

Source: Booz, Allen & Hamilton Inc. estimates

The can manufacturing industry in Tennessee is part of an integrated nationwide network (the greatest volume of cans are produced by firms with nationwide operations for customers who source their products nationwide), of facilities using established and nonproprietary technology. Therefore, Tennessee costs can be readily estimated from data developed on a nationwide basis.

Extrapolation of the costs to the statewide industry requires, first, segmenting the industry in Tennessee according to the types and number of major cans produced, quantifying emissions from each type of can production and identifying the 1977 level of controls, if any, to develop a 1977 baseline case. Second, the likely industry response to the regulations must be developed; and finally, the cost of implementing this response must be calculated. The data and estimates necessary to perform this extrapolation have been presented in previous sections.

- Can production (in units) by type was presented in section 3.2.3.
- Emissions (per million cans) from the production of cans using the various coating operations were presented in Exhibits 3-7, 3-8 and 3-9 and combined on Exhibits 3-12 and 3-13, for several control alternatives for the major types of cans.
- Theoretical uncontrolled emissions were calculated by multiplying the number of cans of each type by the 1977 base case alternative on Exhibits 3-12 and 3-13. This estimate of 717 tons was presented in section 3.3.2.
- The 1977 base line level was assumed to be the theoretical uncontrolled level since no incineration or low solvent coatings were used. (Low solvent coatings were used in 1978.)

The industry response in 1982 to the RACT alternative was presented in section 3.3.4 and summarized on Exhibit 3-11. It included a discussion of the cost and emission reductions from the theoretical level of uncontrolled emission. Exhibit 3-15, on the following page, shows that likely industry capital expenditures of $125,000 will be required to comply with RACT. The annual compliance cost is estimated at $160,000. It is important to note that the largest can plant is being shut down for economic reasons. This plant was the source of over 60 percent of the emissions. The capital cost to the can industry, excluding this plant, is believed to be $125,000; the annual compliance cost, $44,000; and the emission reduction, 112 tons.

Annual average unit cost of emission reduction caused by RACT is estimated to be $393 per ton. Three-piece food and other can assembly has a high unit cost, $5,000 per ton.

EXHIBIT 3-15 (1)
U.S. Environmental Protection Agency
COST OF COMPLIANCE TO RACT FOR THE
CAN MANUFACTURING INDUSTRY IN TENNESSEE

Can Type	Can Production (millions of units)				Capital Investment ($ thousand)			
	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total
3-Piece Beer and Soft Drink	350	50	100	500	120	30	40	190
3-Piece Food and Other Cans	50	50	0	100	20	40	0	60
SUBTOTAL	400	100	100	600	140	70	40	250
Less American Can Co. Memphis plant being shut down for economic reasons								125
TOTAL RACT								125

EXHIBIT 3-15 (2)
U.S. Environmental Protection Agency

Can Type	Annual Compliance Cost ($ thousand)				Emission Reduction (tons)				
	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Waterborne Or Other Low Solvent Coatings	Thermal Incineration With Primary Heat Recovery	Low Solvent Coatings Except End Sealant Which Is Incinerated	Total	Unit Cost Of Emission Reduction ($ per ton)
3-Piece Beer and Soft Drink	30	29	20	79	421	23	120	564	140
3-Piece Food and Other Cans	5	10	0	15	2	1	0	3	5,000
SUBTOTAL	35	39	20	94	423	24	120	567	166
Less Memphis Plant				40				(455)	—
TOTAL RACT				44				112	393

---

a. Not applicable

Source: Booz, Allen & Hamilton Inc.

The substantial cost of developing, testing and obtaining FDA approval of low solvent coatings has not been included in this evaluation, because it is outside the scope of this study and the bulk of it will probably be incurred at the national level. An evaluation of these costs and the degree to which they should properly be allocated to each state must be undertaken on a national basis.

A factor that should be taken into account is that the analysis assumes that production lines will be converted in proportion to the number of cans made by each production mode. Where a single line makes several types of cans, a portion of which can be converted to low solvent systems, the production line might still require installation of afterburner control under RACT requirements, though its use would only be intermittent. The potential effect of this on the cost estimates is difficult to quantify. It is discussed below.

If we assume that all sheet coating and three-piece assembly lines were required to install incinerators, to maintain capability to utilize both conventional and low solvent coatings, the projections would be changed as follows:

- Capital expenditure would be increased by $125,000 or 140 percent.
- Annual cost would increase by $44,000. This represents the capital related costs only.
- Emissions reduction estimates would be unchanged.

The figures presented above represent outside limits with actual experience likely to fall somewhere between the two figures. Since most of the can fabrication facilities in Tennessee are dedicated to beverage cans, for which low solvent coatings systems are likely to be developed by 1982, the effect of this capability maintenance factor will be felt on relatively few production lines.

3.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including: availability of equipment and capital; feasibility of the control technology; and impact on economic indicators such as value of shipments, unit price, state economic variables and capital investment.

3.5.1 RACT Timing

RACT must be implemented statewide by 1982. This implies that can manufacturers must have either low solvent coatings or VOC control equipment installed and operating within the next three years. The timing of RACT imposes several requirements on can manufacturers including:

- Obtaining development quantities of low solvent coatings from their suppliers and having them approved by their customers
- Having coating makers obtain FDA approval where necessary
- Obtaining low solvent coatings in sufficient quantity to meet their volume requirements
- Acquiring the necessary VOC control equipment
- Installing and testing incinerators or other VOC control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

3.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

The can manufacturing industry, in conjunction with coating suppliers and incinerator vendors, has extensively evaluated most of the approaches to meeting RACT. The feeling in the industry is that, but for one notable exception, RACT can be achieved by 1982, using low solvent coatings--primarily waterborne. The coating most likely to be unavailable in 1982 is the end sealing compound. The physical characteristics of this material, as well as its method of application, do not lend themselves to incineration. Currently, the coating is air dried over a period of 24 hours.

The can manufacturers have shut down a significant number of three-piece can manufacturing facilities. It appears likely that the implementation of RACT will accelerate this trend because of the lower cost of compliance with two-piece cans and the probable reluctance on the part of can manufacturers to invest capital in facilities producing products with declining demand.

3.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annualized cost of implementing RACT with the total value of cans sold in the state, the value of wholesale trade in the state and the unit price of cans.

The net incremental annualized cost to can manufacturers is estimated to be about $44,000 (0.3 percent of the value of shipments).

3.5.4 Ancillary Issues Relating to the Impact of RACT

This section presents two related issues that were developed during the study.

The can manufacturers are seeking to have the guidelines altered to encompass a plantwide emissions basis. This would allow a credit from one operation, where emissions were reduced to below the RACT recommended level, to be applied to another operation that is not in compliance. The plant would be in compliance if the total emissions were reduced to the level proposed in RACT. It appears that the impact of this proposed regulation, if accepted, would be to further concentrate the difficult-to-control emissions, such as ending sealing compounds, into the largest facilities and to reduce further the number of can assembly plants.

High solvent coatings represent a considerable fire hazard. The conversion to low solvent coatings has reduced fire insurance costs for at least one can manufacturing facility.

* * * *

Exhibit 3-16, on the following page, presents a summary of the current economic implications of implementing RACT for can manufacturing plants in the State of Tennessee.

EXHIBIT 3-16(1)

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR CAN MANUFACTURING PLANTS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are six or seven can manufacturing facilities; however, the largest is being shut down for economic reasons
Indication of relative importance of industrial section to state economy	1977 value of shipments was $40 million to $45 million. Industry is closely related to state's food and beverage industries
Current industry technology trends	Beer and beverage containers rapidly changing to two-piece construction
1977 VOC emissions (actual)	260 tons per year excluding 455 tons at plant being shut down
Industry preferred methods of VOC control to meet RACT guidelines	Low solvent coatings (waterborne)
Assumed method of control to meet RACT guidelines	75 percent of cans coated with low solvent coatings; 25 percent of coated cans requiring incinerator for control

Affected Areas in Meeting RACT	Discussion
Capital investment statewide (excluding shut down facility)	$125,000 (less than 5 percent of current annual capital appropriations for the industry
Annualized cost (statewide excluding shut down facility	$44,000 (approximately 0.3 percent of the industry's 1977 statewide value of shipments, excluding the shutdown plant)
Price	Assuming a "direct cost pass through" less than $0.0001 can increase (based on a can value of $0.075 per can)
Energy	Increase of 1,000 to 1,500 equivalent barrels of oil annually for operation of facilities that have to utilize incinerators
Productivity	No major impact
Employment	No major impact

EXHIBIT 3-16(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Market structure	Accelerated technology conversion to two-piece cans, further concentration of sheet coating operations into larger facilities
RACT timing requirements (1982)	Low solvent coating volume requirements and FDA approval may require some facilities to meet the RACT requirements with incinerations (rather than low solvent coating technology)
Problem area	Low solvent coating technology for end sealing compound
VOC emission after RACT control	150 tons per year (21 percent of 1977 emission level or 58 percent of emissions from affected plants)
Cost effectiveness of RACT control excluding shut down facility	$390 to $400 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Control of Volatile Organic Emissions from Existing Stationary Sources, EPA-450/2-77-008, May 1977.

Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, Enfield, CT, August 23, 1977

Private conversations at the following companies:

American Can Company, Greenwich, Connecticut
National Can Company, Chicago, Illinois
Diamond International, Dandridge, Tennessee
Stokley Van Camp, Newport, Tennessee
Ring Can Company, Oakland, Tennessee
Boise Cascade, Jackson, Tennessee

4.0 THE ECONOMIC IMPACT OF IMPLEMENTATION OF RACT GUIDELINES TO THE SURFACE COATING OF COILS IN THE STATE OF TENNESSEE

As will be shown in this chapter, there are two coil coating operations in the state of Tennessee[1] potentially affected by the implementation of RACT standards. The economic impact, although significant to some of the individual firms affected, is minor relative to the overall industry capital investment and operating cost.

This chapter is divided into four sections:

- Specific methodology and quality of estimates
- Applicable RACT guidelines, timing and control technology
- Coil coating operations in the state of Tennessee
- Direct economic implications

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[1] The three urban nonattainment counties are: Davidson, Hamilton and Shelby. In these counties all sources with potential emissions of 25 tons or more per year are included in the analysis. For the rest of the state, all sources with potential emissions of 100 tons or more per year are included in the analysis.

4.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impacts

for the surface coating of coils in Tennessee.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

4.1.1 Industry Statistics

Coil coating is listed under Standard Industrial Classification (SIC) 3479. Our methodology to gather statewide statistical data on coil coating in Tennessee was as follows:

- A list of potentially affected facilities was compiled in conjunction with state EPA authorities and trade association sources.

- The states EPA supplied relevant information, such as number of coating lines, on the operations potentially affected.

4.1.2 VOC Emissions

In the state of Tennessee, two coil coating facilities were identified. The following sources were utilized to identify VOC emitters in this industry category:

- Tennessee EPA emission inventory
- National Coil Coaters Association
- Tennessee Directory of Manufacturers, 1978.

4.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for the surface coating of coils are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks, EPA-405/2-77-008, May 1977.

4.1.4 Cost of Control of VOC Emissions for Surface Coating of Coils

The costs of control of volatile organic emissions for surface coating of coils were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Defining a model plant
- Applying the costs developed by Springborn Laboratories (under EPA contract number 68-02-2075, August 23, 1977) to the most likely alternative types of control:
    - Installed capital cost
    - Direct operating cost
    - Annual capital charges
    - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

4.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Tennessee.

4.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of coils in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 4-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 4-1
U.S. Environmental Protection Agency
SURFACE COATING OF COILS
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics			X
Emissions	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

4.2 APPLICABLE RACT STANDARDS, TIMING AND CONTROL TECHNOLOGY

This section includes a review of:

- Applicable RACT standards
- RACT timing
- The technology of coil coating
- Commercial aspects of the business
- Approved control technologies
- Estimated capital and operating costs to control VOC emissions.

4.2.1 Approved RACT Standards

As indicated in the EPA guidelines Article XX.9204, subpart (d) (1):

> ...no owner or operator of a coil coating line... may cause, allow or permit discharge into the atmosphere of any volatile organic compounds in excess of 0.31 kilograms per liter of coating (2.6 pounds per gallon), excluding water, delivered to the coating applicator from prime and topcoat or single coat operations.

Thus, of the approximately 4 to 6 pounds of VOC contained in a gallon of paint to be applied with conventional coil coating techniques, the operator must not allow emission of more than 2.6 pounds. The reduction in emissions may be achieved by utilization of low solvent content coating technology, thermal incineration or other approved methods.

4.2.2 RACT Timing

There are three RACT final compliance schedules for Tennessee. They are as follows:

- Low solvent coating implementation by September 1, 1981
- Equipment modification implementation by November 1, 1981
- Add-on control system implementation by November 1, 1981.

4.2.3 The Technology of Coil Coating

Coil coating is the coating of any flat metal (aluminum or steel typically) sheet or strip that comes in rolls or coils. This process consists of taking the coil through a series of steps in one continuous process. Generally, these steps include:[1]

- Cleaning--removal of mill-applied protective oils, dirt, rust and scale
- Rinsing--removal of the products of the cleaning process
- Pretreating--with chemicals such as iron and zinc phosphates, chromates and complex oxides to prepare the metal for coatings
- Rinsing--after the pretreatment
- Painting--commonly by application of primer and finish coats with a "reverse" roller technique in which the roll applying the coating turns in the opposite direction of the metal being coated
- Curing--all coatings are cured in seconds as they pass through ovens, mostly of the convection or hot air type. At the end of the curing operation, the coated metal is recoiled for shipment.

Configurations of coil coating lines differ. On some lines, the metal is uncoiled at one end of the line and recoiled at the opposite end. On other lines, called "wrap around" lines, the metal is uncoiled and recoiled at about the same point on the line. Some coil coating lines have a single coater and one curing or baking oven; others, called "tandem" lines, have several successive coaters each followed by an oven, so that several different coatings may be applied in a single pass. Exhibit 4-2, on the following page, is a schematic of a "tandem" coil coating line.

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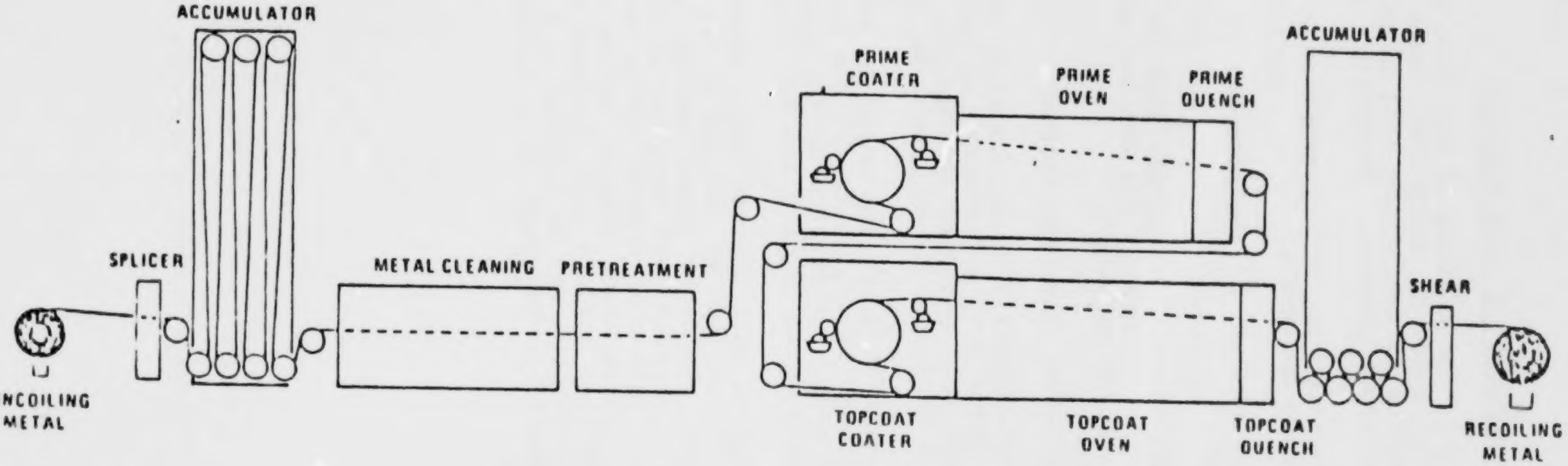
[1] National Coil Coaters Association brochure

EXHIBIT 4-2
U.S. Environmental Protection Agency
DIAGRAM OF A COIL COATING LINE


ACCUMULATOR
SPLICER
UNCOILING METAL
METAL CLEANING
PRETREATMENT
PRIME COATER
PRIME OVEN
PRIME QUENCH
TOPCOAT COATER
TOPCOAT OVEN
TOPCOAT QUENCH
ACCUMULATOR
SHEAR
RECOILING METAL

urce: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

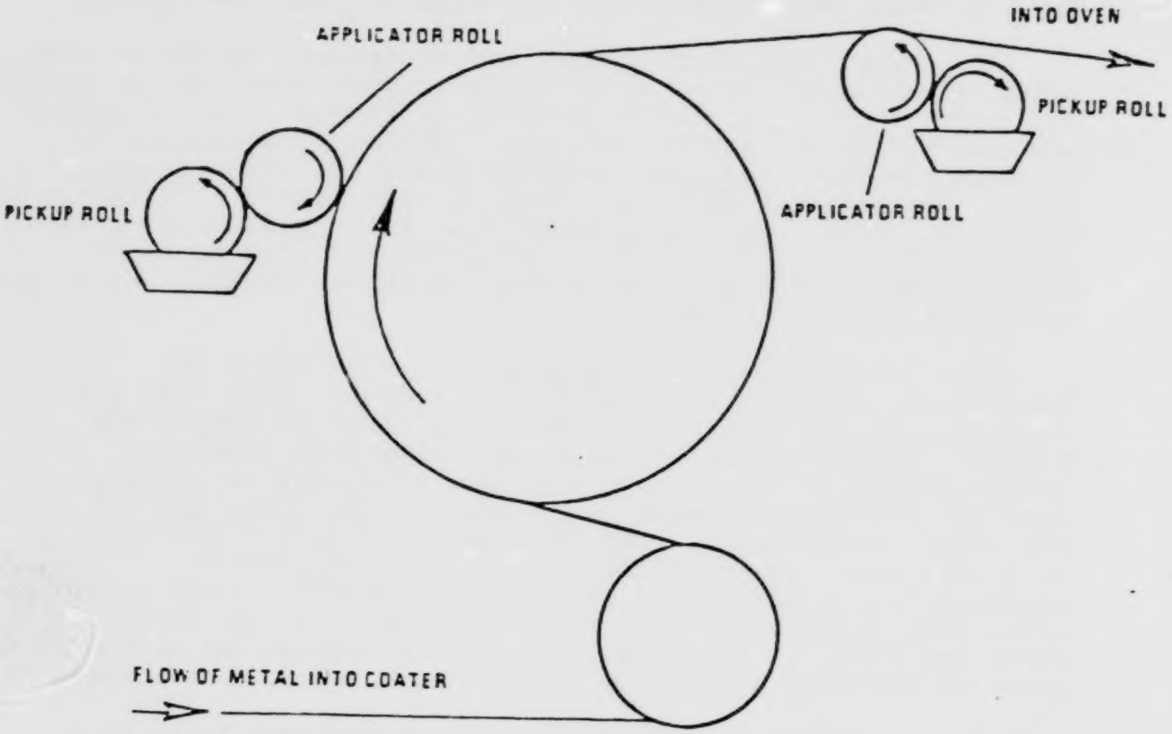
The metal on the coil coating line is moved through the line by power-driven rollers. It is uncoiled as the process begins and goes through a splicer, which joins one coil of metal to the end of another coil for continuous, nonstop production. The metal is then accumulated so that, during a splicing operation, the accumulator rollers can descend to provide a continuous flow of metal throughout the line. The metal is cleaned at temperatures of 120°F to 160°F, brushed, and rinsed to remove dirt, mill scale, grease and rust before coating begins. The metal is then treated for corrosion protection and for proper coating adhesion with various pretreatments, depending on the type of metal being coated and the type of coatings applied.

The first coat or primecoat may be applied on one or both sides of the metal by a set of three or more power-driven rollers. The pick-up roll, partially immersed in the coating, transfers the coating to the applicator roll. The metal is coated as it passes between the applicator roll and the large back-up roll. The metal is typically reverse roll coated. Exhibit 4-3, on the following page, is a schematic of a typical roll coater. A third roll, called a "doctor" roll, may be used to control film thickness when applying a high viscosity coating, by making contact with the pick-up roll.

The applied coating is usually dried or baked in a continuous, catenary or flotation or a double-pass oven that is multizone and high production. The temperatures of the preheat, drying or baking zones may range from 100°F to 1000°F depending on the type and film thickness of coating used and the type of metal being coated. The flow rates of the ovens' exhausts may vary from approximately 4,000 scfm to 26,000 scfm. Many of these ovens are designed for operation at 25 percent of the room-temperature lower explosive level when coating at rated solvent input. As the metal exits the oven, it is cooled in a quench chamber by either a spray of water or a blast of air followed by water cooling.

A second coat or topcoat may be applied and cured in a manner similar to the primecoat. The topcoat oven, however, is usually longer than the primecoat oven and contains more zones.

EXHIBIT 4-3
U.S. Environmental Protection Age
TYPICAL REVERSE ROLL COATER


INTO OVEN
APPLICATOR ROLL
PICKUP ROLL
PICKUP ROLL
APPLICATOR ROLL
FLOW OF METAL INTO COATER

Source: Control of Volatile Organic Emissions from Existing Stationary Sources-Volume II; Surface Coatings of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks (EPA, 405/2-77-008, May 1977).

Reproduced from best available copy.

Another method of applying a primecoat on aluminum coils or a single coat on steel coils is to electrodeposit a waterborne coating to either one or both sides of the coil. The coil enters a V-shaped electrocoating bath that contains a roll on the bottom. As the metal goes around the roll, electrodes on each side can be activated and permit the coagulation of the paint particles on either one or both surfaces of the coil. The coated coil is then rinsed and wiped by squeeges to remove the water and excess paint particles. For steel coils, the electrodeposited coating must be baked in an oven. For aluminum coils, however, the primecoat is stable enough to go over rolls immediately to the topcoat coater without destroying the finish, and then be baked as a two-coat system.

After cooling, the coated metal passes through another accumulator, is sheared at the spliced section, usually waxed and finally recoiled. The accumulator rolls rise during the shearing process, collecting the coated metal to ensure continuous production.

Organic vapors are emitted in three areas of a coil coating line: the areas where the coating is applied, the oven and the quench area. The oven emits approximately 90 percent of the organic vapors and a majority of the other pollutants. Of the remaining 10 percent of hydrocarbons emitted, approximately 8 percent are emitted from the coater area and approximately 2 percent are emitted from the quench area.

4.2.4 Commercial Aspects of the Business

Coil coating was first practiced in the 1930s as a technique to coat metal for venetian blinds. As the technical, operating and economic advantages became apparent, the industry experienced remarkable growth. Since 1962, for example, estimated shipments have shown an average annual growth rate of some 16.5 percent. By 1977, as shown in Exhibit 4-4, on the following page, more than four million tons of aluminum and steel were coated using this method.

In terms of dollars, the four million tons of coated coil produced in the U.S. in 1977 represented a total product value of some $3.5 billion. Other pertinent indicators of the scale of this business include the following:

- Approximately 13 billion square feet of coated coil were produced.

EXHIBIT 4-4

Environmental Protection Agency

ESTIMATED TONNAGE OF METAL COATED IN THE U.S. IN 1977 WITH COIL COATING TECHNIQUES

Market	Steel Shipments (tons)	Aluminum Shipments (tons)
Building products	1,100,000	610,000
Transportation	1,400,000	100,000
Appliances	140,000	25,000
Containers, packaging	80,000	200,000
Furniture, fixtures and equipment	110,000	15,000
Other uses	220,000	50,000
	3,050,000	1,000,000

Source: National Coil Coaters Association statistics.

- Organic coatings of several types currently utilized by the coil coaters in North America represent 19 million gallons. These, coupled with various types of film laminates, represent a total estimated value of $140 million in coatings.

- Chemical pretreatment for coil coaters is estimated at a value of $10 million.

- It requires approximately 12.8 billion cubic feet of natural gas and 4.1 million gallons of propane to cure these coatings. To coat the equivalent metal by "post painting" would require approximately five times this amount of energy.

- Today, there are 182 coil coating lines in North America, ranging in maximum coil width capacity from 2 to 60 inches and capable of running at maximum speed from 100 to 700 feet per minute.

- If all these lines were running at full capacity, it is estimated that they could coat more than 20 billion square feet of metal per year.

4.2.5 Approved Control Technologies

Per the Environmental Protection Agency Guidelines in Article XX.9204, subpart (d)(2), the emission limit shall be achieved by:

- The application of low solvent content coating technology; or

- Incineration, provided that 90 percent of the nonmethane volatile organic compounds (VOC measured as total combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or

- A system demonstrated to have control efficiency equivalent to or greater than provided under the preceding paragraphs. . .and approved by the Director.

4.2.6 Estimated Capital and Operating Costs to Control VOC Emissions

Estimates of capital and operating costs to control VOC emissions from coil coating operations were prepared by Springborn Laboratories, Inc., for the Environmental Protection Agency (Contract No. 68-02-2075, August 23, 1977). These estimates are discussed in this section.

The model chosen handles material 40 inches wide and coats at a speed of 300 feet per minute. This yields a yearly production of 204 million square feet when operated for 4,000 hours per year. The material usage is 344,630 gallons of paint and 34,460 gallons of solvent per year.

Case I	The base case with no controls for emissions; shows the cost of a new line using conventional enamel coating which does not meet RACT
Case II	The use of waterborne coating materials with no additional treatment of emissions
Case III	The base case with a thermal incinerator on each of the primecoat and topcoat ovens. Due to the relation of the coating applicator to the curing oven, the oven exhausts are assumed to be 90 percent of total emissions. The incinerator is figured with primary heat exchange to minimize the fuel costs and operates at an average 90 percent efficiency.

Emission control costs for each of the cases studied are summarized in Exhibit 4-5, on the following page. As indicated, additional capital costs to install emission control systems range from $50,000 to $254,000 over the base case capital cost depending on the alternative selected. Operating costs range from $8,000 to $75,000 more than the base case, or 0.3 percent to 2.5 percent increased cost per unit. Costs per ton of solvent range from $11 to $112.

EXHIBIT 4-5
U.S. Environmental Protection Agency
SUMMARY OF EMISSION CONTROL COSTS

Output 204,000,000 SF/yr.
(18,950,000 sq. meters)
4,000 hours/year

	Case	Total Investment	Increase over Base Case	Total Annual Cost	Increased Annual Cost over Base Case	Cost/Unit 1000 SF (1000 SM)	Increased Cost Per 1000 SF over Base		Tons (Metric Tons) Solvent Emitted/Yr.	Decreased Emission over Base (Metric Tons)	Emission Reduction	Cost/Ton (Metric Ton) To Remove Solvent
		$	$	$	$	$	$	%			%	$
I	Base Case - solvent-borne primecoat & topcoat	3,300,000	-	2,977,400	-	14.59 (157.05)	-	-	832.3 (755)	-	-	
II	Waterborne primecoat & topcoat	3,350,000	50,000	2,985,800	8,400	14.64 (157.58)	0.05	0.3	98.9 (89.9)	733.4 (665.1)	88	11.45 (12.63)
III	Base Case with thermal incinerators on ovens; primary heat recovery	3,554,260	254,260	3,052,860	75,460	14.96 (161.03)	0.37	2.5	158.1 (143.5)	674.2 (611.5)	81	111.93 (123.40)

Source: Springborn Laboratories, Air Pollution Control Engineering and Cost Study, op. cit.

4.3 COIL COATING OPERATIONS IN THE STATE OF TENNESSEE

From information provided by Tennessee EPA, it was determined that there are two coil coating facilities in the state of Tennessee. Details pertinent to these operations are shown in Exhibit 4-6, on the following page.

Tennessee EPA reports that each coil coating facility has one operating line and that Alcoa intends to use low solvent technology to meet the RACT guideline requirements. Conalco has indicated it will implement thermal incineration to meet the RACT guideline requirements.

EXHIBIT 4-6
U.S. Environmental Protection Agency
COIL COATING OPERATIONS IN TENNESSEE

Company	Location	No. of Lines	Current Hydrocarbon Emissions	Control Efficacy With RACT	Potential Emission Reduction With RACT
			(Tons/Yr.)	(percent)	(Tons/Yr.)
Alcoa	Alcoa, Tennessee	1	599	80	479
Consolidated Aluminum Corp.	Jackson, Tennessee	1	396	80	317
TOTAL		2	995		796

Source: Tennessee EPA and Booz, Allen & Hamilton Inc.

4.4 DIRECT ECONOMIC IMPLICATIONS

As was shown in Exhibit 4-6, two coil coating firms in Tennessee (with two coating lines) are subject to the RACT standards. One coil coating operation is expected to substitute low solvent coatings to meet the RACT limitations while the other is expected to use incineration. Based on the model plant costs (assumption that no major changes in existing process equipment would be required) the capital cost is estimated at $300,000, and annualized cost is estimated at $84,000 per year. Most of this cost is for the facility which is planning to install incineration for the control of VOC emissions.

* * * * * *

Exhibit 4-7, on the following page, summarizes the findings presented in this chapter.

EXHIBIT 4-7
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR COIL COATING FACILITIES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are two coil coating facilities with two lines potentially affected by the coil coating RACT guideline in Tennessee
Current industry technology trends	Due to the pressures of energy availability as well as environmental protection, most firms have or are installing regenerative type incinerators
1977 VOC emissions (actual)	Approximately 1,000 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Regenerative thermal incineration
Assumes method of control to most RACT guidelines	Regenerative thermal incineration and low solvent coatings

Affected Areas in Meeting RACT	Discussion
Capital Investment (statewide)	$0.3 million incremental capital required by two firms based on model plant costs
Annualized Cost (statewide)	$84,000
Energy	Small increased fuel consumption for regenerative incineration
Productivity	No major impact
Employment	No major impact
Market structure	Some captive coil coating operations not meeting the RACT limitation may opt to purchase coated material in lieu of investing significant capital requirements
RACT timing requirements	There may be delivery and installation problems if major coating industry sectors who require incinerators, order and install similar equipment in the same time frame
Problem area	Low solvent coating technology is currently inadequate to meet product requirements in all applications
VOC emission after control	Approximately 200 tons per year (20 percent of 1975 VOC emission level)
Cost effectiveness of control	$84 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

Springborn Laboratories, Inc., Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report. EPA Contract No. 68-02-2075, August 23, 1977.

U.S. Environmental Protection Agency, Control of Voltatile Organic Emissions from Existing Stationary Sources, Volume II. Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks

Private conversations with:

National Coil Coaters Association

5.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING PAPER IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Tennessee which are engaged in the surface coating of paper. This is meant to include protective or decorative coatings put on paper, pressure-sensitive tapes regardless of substrate, related web coating processes on plastic film and decorative coatings on metal foil, but does not include conventional printing processes which apply inks.

The chapter is divided into five sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines; previous studies of paper coating; interviews with paper coaters, coating equipment and materials manufacturers; and a review of pertinent published literature.

5.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for plants engaged in the surface coating of paper. The quality of these estimates is discussed in the last part of this section.

5.1.1 Industry Statistics

Paper coating is practiced in a number of industries. Among products that are coated using organic solvents are: adhesive tapes; adhesive labels; decorated, coated and glazed paper; book covers; office copier paper; carbon paper; typewriter ribbons; photographic film; paper cartons; and paper drums. The firms coating paper are classified in a number of groupings in the U.S. Department of Commerce's Standard Industrial Classification system. The major coaters may be found in the following 16 SIC groups:

SIC	Description
2611	Pulp mills
2621	Paper mills, except building paper mills
2631	Paperboard mills
2641	Paper coating and glazing
2643	Bags, except textile bags
2645	Diecut paper and paperboard and cardboard
2649	Paper converting, n.e.c.
2651	Folding paperboard boxes
3291	Abrasive products
3292	Asbestos products
3293	Gaskets, packing and sealing devices
3497	Metal foil and leaf
3679	Electronic components, n.e.c.
3842	Orthopedic, prosthetic and surgical appliances and supplies
3861	Photographic equipment and supplies
3955	Carbon paper and inked ribbons

This list does not include plants listed in the SIC category 2700 (Printing, Publishing and Allied Industries), where paper coating other than printing may also be a part of the overall processing of the printed product.

Statistics concerning these industries were obtained from a number of sources. All data where possible were converted to the base year 1977 for the state using scaling factors developed from U.S. Department of Commerce data as presented in County Business Patterns. The primary sources of economic data were the 1972 Census of Manufactures and 1976 Annual Survey of Manufactures.

The list of firms likely to be affected by the proposed regulation was compiled from data provided by the Tennessee Division of Air Pollution Control, the Memphis and Shelby County Health Department, and the Hamilton County Air Pollution Control Bureau.

Of 17 firms identified as likely to be affected by the proposed regulation, 10 were found to have potential emissions[1] which exceed the standards. That is, they have potential emissions greater than 25 tons per year in Hamilton, Shelby and Davidson Counties (urban non-attainment counties) and greater than 100 tons per year in the rest of the state. One firm, CPS Industries, located in Williamson County, had potential emissions over 100 tons per year, but it was excluded from the list of affected firms because it performs printing on paper and dip coating of industrial tape, both of which processes are not covered by the proposed regulation.

5.1.2 VOC Emissions

The VOC emissions data for the affected firms were provided by Tennessee Division of Air Pollution Control and the three local air pollution control agencies mentioned in the preceding section.

5.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from sources included in the paper coating category are described in Control of Volatile Organic Emissions From Existing Stationary Sources, Volume II (EPA-450/2-77-008). The feasibility of applying the various control methods to paper coating discussed in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

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[1] Potential emissions are those from a plant operated at rated capacity for 24 hours per day 365 days a year.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The situations where emissions are likely to be controlled by reformulation and by control devices were estimated based on a review of the literature and on information obtained from interviews with several of the Tennessee coaters.

5.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions in accord with the proposed regulations were determined from:

- Generalized cost formulae based on estimated emissions and judgment as to the type of control to be used
- A development of capital, operating and energy requirements for the facilities that will be affected, based on the generalized cost correlations
- Aggregation of the findings for each plant affected.

The generalized cost correlations used are to be found in:

- Control of Volatile Organic Emissions From Stationary Sources, Volume I (EPA-450/2-76-028)
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Additional cost data were supplied by equipment and material suppliers and published literature sources. Major coaters in other states have been consulted to determine industry views on acceptable control methods and, in some cases, to confirm the cost estimating formulae.

5.1.5 Economic Impacts

The projected effect of RACT implementation on price is based on an indicator which is the incremental cost related to the total sales or cost of the product within the state. The procedure is described below:

- Relate incremental costs to total statewide figures
- Also relate incremental costs to the part of the statewide production that is affected by the regulation (firms not now meeting RACT)
- Where data is available, show the range of ratios for individual locations
- Where the industry has been segmented, show the range of cost ratios for applicable industry segments.

The cost per unit of production is an indicator of potential price effect rather than a prediction of the price effect to be expected.

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in the state.

5.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of paper in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 5-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 5-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF PAPER

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

5.2 INDUSTRY STATISTICS

Industry characteristics, statistics and trends for paper coating in Tennessee are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in the state and for the effect upon individual firms.

5.2.1 Size of the Industry

The 1978 Tennessee Directory of Manufacturers reports a total of 121 firms in 16 SIC categories in Tennessee where paper coating, as defined in proposed RACT guidelines, is the main business of the firm or may be a part of its manufacturing activity. The number of firms and other relevant statistics in each SIC grouping are summarized in Exhibit 5-2.

Total value of shipments for these firms is estimated to be about $1.09 billion, with a total of about 15,300 employees. New capital expenditures are estimated to be about $83 million annually, based on the most recent (1976) Annual Survey of Manufactures.

Of the total 121 firms, 10 have been identified as actual paper coaters with potential emissions exceeding RACT standards. (These are listed in Exhibit 5-5 in Section 5.3.5). Of the ten firms one is in the process of converting its operation entirely to waterbased coating materials leaving nine firms directly impacted by the proposed regulation. The total annual value of shipments of the nine firms is estimated at $443 million based on an average of $70,000 of shipments per employee which is characteristic of firms in SIC 2641, paper coating.

5.2.2. Comparison of the Industry to the State Economy

A comparison of the value of shipments of the 121 plants in the 16 SIC categories listed in Section 5.1.1 with the total state manufacturing economy ($21.8 billion) indicates that these plants represent about 20 percent of the total value of manufacturing shipments in Tennessee. These 121 firms employ about 3.4 percent of the 452,000 manufacturing employees in the state. The nine affected firms' operations represent 2.0 percent of the total value of manufacturing shipments in Tennessee and employ about 1.4 percent of all manufacturing employees.

Because several of the firms manufacture other goods in addition to coated paper, the figures cited above probably represent an upper limit on the value of shipment of coated paper products in the state.

5.2.3 Historical and Future Patterns of the Industry

The nationwide value of shipments in the industries expected to be affected by the proposed paper coating regulations, in general, exceed the growth rate of the economy. As summarized in Exhibit 5-3, the value of shipments increased in every category between 1972 and 1976, with an average annual growth rate of about 12.1 percent over the period. Compared to an average inflationary rate of 6 to 8 percent, this is equivalent to a real growth rate of 4 to 6 percent. In some individual categories, growth rates were even greater. Paper production increased by an uncorrected average annual growth rate of 16.5 percent; metal and foil by 16 percent; paper coating and glazing by about 12 percent, only slightly less than the average. It is expected that the growth rate will continue at these rates for the near future.

5.3 TECHNICAL SITUATION IN THE INDUSTRY

This section briefly describes the general process and materials used in the surface coating of paper and similar products proposed to be included under the RACT Surface Coating of Paper regulations. The technology is fully described in the RACT documents.[1] The products include a myriad of consumer and industry oriented items, such as pressure-sensitive tapes, adhesive labels, book covers, milk cartons, flexible packaging materials and photographic film. Although many of these products are also printed in one manner or another, the emissions from printing inks are not included in the RACT regulations pertaining to paper coating; only the emissions specifically issuing from the coating operation are included. An estimate of these emissions for the state is also presented in this section.

5.3.1 General Coating Process Description

In organic solvent paper coating, resins are dissolved in an organic solvent mixture and this solution is applied to a web (continuous roll) of paper. As the coated web is dried, the solvent evaporates and the coating cures.

Most organic solventborne coating is done by paper converting companies that buy paper from the mills and apply coatings to produce a final product. The paper mills themselves sometimes apply coatings, but these are usually waterborne coatings consisting of a pigment (such as clay) and a binder (such as starch or casein). However, much additional coating is done by firms only as part of the manufacturing process.

Solvent emissions from an individual coating facility will vary with the size and number of coating lines. A plant may have one or as many as 20 coating lines. Uncontrolled emissions from a single line may vary from 50 pounds per hour to 1,000 pounds per hour, depending on the line size. The amount of solvent emitted also depends on the number of hours the line operates each day.

Exhibit 5-4 gives typical emission data from various paper coating applications.

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[1] Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II, EPA-450/2-77-008

5.3.2 Nature of Coating Materials Used

The formulations usually used in organic solventborne paper coatings may be divided into the following classes: film-forming materials, plasticizers, pigments and solvents. Dozens of organic solvents are used. The major ones are: toluene, xylene, methyl ethyl ketone, isopropyl alcohol, methanol, acetone and ethanol.

Although a single solvent is frequently used, often a solvent mixture is necessary to obtain the optimum drying rate. Too rapid drying results in bubbles and an "orange peel" effect in the coating; whereas, slow drying coatings require more time in the ovens or slower production rates. Variations in the solvent mixture also affect the solvent qualities of the mix.

The main classes of film formers used in conventional paper coating are cellulose derivatives and vinyl resins. The most commonly used cellulose derivative, nitrocellulose, has been used for paper coating decorative paper, book covers and similar items since the 1920s. It is relatively easy to formulate and handle, and it dries quickly, allowing lower oven temperatures than vinyl coatings. The most common vinyl resin is the copolymer of vinyl chloride and vinyl acetate. These vinyl copolymers are superior to nitrocellulose in toughness, flexibility and abrasion resistance. They also show good resistance to acids, alkalies, alcohols and greases. Vinyl coatings tend to retain solvent, however, so that comparatively high temperatures are needed. In general, nitrocellulose is most applicable to the decorative paper field, whereas vinyl copolymers are used for functional papers, such as some packaging materials.

In the production of pressure-sensitive tapes and labels, adhesives and silicone release agents are applied using an organic solvent carrier. The adhesive layer is usually natural or synthetic rubber, acrylic or silicone. Because of their low cost, natural and synthetic rubber compounds are the main film formers used for adhesives in pressure-sensitive tapes and labels, although acrylic and silicone adhesives offer performance advantages for certain applications. In most cases, tapes and labels also involve the use of release agents applied to a label carrier or the backside of tape to allow release. The agents are usually silicone compounds applied in a dilute solvent solution.

5.3.3 Current VOC Emissions and Controls

A summary of the emissions from plants likely to be affected by the proposed regulations for the paper coating RACT category is presented in Exhibit 5-5. The emissions for the plants listed are believed to represent the bulk of paper coating emissions in the state.

Currently, Polymer Technology, Inc. is in the process of converting its paper coating operations from solvent based to waterbased coating. This conversion is expected to be completed within the next two years.

Another firm, Holliston Mills, recirculates a part of the air used in the drying oven through an open flame heater, which is believed to oxidize some of the hydrocarbons evaporated in the drying oven. However, the amount of hydrocarbons oxidized is not known.

Thus, the total VOC emissions for plants likely to be subject to control under the proposed regulations in Tennessee are 12,036 tons per year, of which 12,008 tons are from the nine plants that would be directly impacted by the regulations.

5.3.4 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of paper require that emission discharges of VOCs be limited to 2.9 pounds per gallon of coating material delivered to the coating applicator.

The recommended methods of achieving this requirement are:

- The application of low solvent content coatings; or
- Incineration, provided that 90 percent of the nonmethane VOCs (measured as combustible carbon) which enter the incinerator are oxidized to carbon dioxide and water; or
- A system demonstrated to have control efficiency equivalent to or greater than provided by either of the above methods.

EXHIBIT 5-5
U.S. Environmental Protection Agency
TENNESSEE ESTIMATES OF PAPER COATING EMISSIONS AS REPORTED TO BOOZ, ALLEN & HAMILTON

Company Name Town (County)	SIC	Employees	Actual Emissions[a] Tons per year	Potential Emissions Tons per year
Bryce Corp. Memphis (Shelby)	3079	100	172	241
Cleo Wrap Corp. Memphis (Shelby)	2649 2771	1,000	3,441	4,880
Dixico, Inc. Memphis (Shelby)	2641	325	1,873	2,622
W.F. Hall Printing Co. Dresden (Weakley)	2721	600	63	110
Holliston Mills, Inc. New Canton (Hawkins)	2789	500	4,566[b]	c
IPC Dennison Rogersville (Hawkins)	2641	350	999	c
Kingsport Press Kingsport (Sullivan)	2731 2782	3,300	46	201
Polymer Technology Smyrna (Rutherford)	2641	20	28	148
Rexham Corp. Memphis (Shelby)	2641	67	374	c
Southern Specialty Paper Chattanooga	2641	68	474	1,991
Totals		6,330	12,036	10,193

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a For the year 1977.

b The emissions for fabric coating are included in the figures shown.

c Not reported.

Source: Booz, Allen and Hamilton, and Tennessee State Emissions Inventory.

5.3.5 Alternative Control Methods

In this section are discussed several methods of low solvent and solventless systems, which have been demonstrated to be applicable to some paper coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008), which should be consulted for a more thorough discussion. In some instances, additional information was obtained from coaters, coating material suppliers and control equipment manufacturers.

5.3.5.1 Low Solvent and Solventless Coatings

In Exhibit 5-6, on the following page, are listed several types of coating materials which have found utility in paper coating, and an estimate of expected solvent reduction. These are briefly discussed in the following paragraphs.

Waterborne coatings have long been used in coating paper to improve printability and gloss. However, newer coatings have been developed in which a synthetic insoluble polymer is carried in water as a colloidal dispersion or an emulsion. This is a two-phase system in which water is the continuous phase and the polymer resin is the dispersed phase. When the water is evaporated and the coating cured, the polymer forms a film that has properties similar to those obtained from organic-solvent-based coatings.

Plastisols are a colloidal dispersion of synthetic resin in a plasticizer. When the plasticizer is heated, the resin particles are solvated by the plasticizer so that they fuse together to form a continuous film. Plastisols usually contain little or no solvent, but sometimes the addition of a filler or pigment will change the viscosity so that organic solvents must be added to obtain desirable flow characteristics. When the volatile content of a plastisol exceeds 5 percent of the total weight, it is referred to as an organisol. Although organic solvents are not evaporated from plastisols, some of the plasticizer may volatilize in the oven. This plasticizer will condense when emitted from the exhaust stack to form a visible emission.

Hot melt coatings contain no solvent; the polymer resins are applied in a molten state to the paper surfaces. All the materials deposited on the paper remain as part of the coating. Because the hot melt cools to a solid coating soon after it is applied, a drying oven is not needed to evaporate solvent or to cure the coating. Energy that would have been used to heat an oven and to heat makeup air to replace oven exhaust is therefore saved. One disadvantage with hot melt coatings is that materials that char or burn when heated cannot be applied by hot melt. Other materials will slowly degrade when they are held at the necessary elevated temperatures.

A type of hot melt coating, plastic extrusion coating is a solventless system in which a molten thermoplastic sheet is discharged from a slotted dye onto a substrate of paper, paperboard or synthetic material. The moving substrate and molten plastic are combined in a nip between a rubber roll and a chill roll. A screw-type extruder extrudes the coating at a temperature sometimes as high as 600°F. Low and medium density polyethylene are used for extrusion coating more than any other types of resins.

Waterborne adhesives have the advantage that they can be applied with conventional coating equipment. Waterborne emulsions, which can be applied less expensively than can solventborne rubber-based adhesives, are already in use for pressure-sensitive labels. A problem with waterborne adhesives is that they tend to cause the paper substrate to curl and wrinkle.

Prepolymer adhesive coatings are applied as a liquid composed of monomers containing no solvent. The monomers are polymerized by either heat or radiation. These prepolymer systems show promise, but they are presently in a developmental stage only.

Silicone release coatings, usually solventborne, are sometimes used for pressure-sensitive, adhesive-coated products. Two low-solvent alternatives are currently on the market. The first is a 100 percent nonvolatile coating which is usually heat cured, but may be radiation cured. The second system is a water emulsion coating which is lower in cost than the prepolymer coating. However, because of wrinkling and other application problems the waterborne coating may be of limited value. Some silicone coating materials which are under development use single solvent systems that can be readily recovered by carbon adsorption. Current coatings are troublesome since some silicone is carried into the adsorber where it clogs the carbon pores to reduce adsorption efficiency.

5.3.5.2 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures above 1,200°F for direct incineration and 700°F for catalytic incineration. Another problem is the generation of nitrogen oxides in direct fired incinerators because of the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot incinerator exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or baking ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from the combustion of the volatile organic compounds in the exhausts.

Paper coaters who use coating machinery for a multiplicity of processes have commented that catalytic incineration would probably not be used because of the possibility of catalyst poisoning. Direct incineration would be used.

5.3.5.3 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on paper coating lines were installed because they were profitable. Pollution control has usually been a minor concern.

Carbon adsorption is most adaptable to single solvent processes. Many coaters using carbon adsorption have reformulated their coatings so that only one solvent is required. Toluene, a widely used solvent for paper coating, is readily captured in carbon adsorption systems.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing recovered solvents may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In some cases, such as in the preparation of photographic films or thermographic recording paper, extremely high purity solvents are necessary to maintain product performance and even distillation may be insufficient to produce the quality of recovered solvent needed. For most other coating formulations, distillation is adequate.

Another problem with carbon adsorption is the potential of generating explosive conditions in the adsorber because of the localized increases in combustible organic material concentrations. Ignition apparently can be caused by static electricity in systems where dry air at high flow rates is treated. Several explosions of absorbers have been reported in paper coating and other plants.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem in the water effluent, where steam is used for regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

5.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for paper coating in the state. Where possible, the validity of the costs were confirmed with coating firms and equipment manufacturers.

Several coaters interviewed in Tennessee indicated their preference for incineration to comply with the RACT guidelines, whereas one firm has already started switching to waterbased coatings and plans to complete the switching within two years. The other firms interviewed had not formulated their control plans. Though some coaters may substitute low solvent or solventless coating for current high solvent systems, no reliable information was available to estimate the amount of such coatings that might be used. Several coaters interviewed in other states commented that though they had low solvent coatings under development the coatings would not be sufficiently evaluated to meet proposed compliance schedules. Similarly, some coaters may use a carbon adsorption system, but no reliable information was available to estimate such use. Therefore, for cost estimating purposes, it has been assumed that the nine directly impacted firms will use incineration to comply with the proposed regulations.

5.4.1 Costs of Control

The incineration system cost estimates for Tennessee were derived from the data from the EPA report EPA-450/2-76-028. Several key assumptions made in deriving these costs are discussed in this section.

First, incinerator costs are a function of equipment size, which varies generally with air flow rate. In most plants, it is impractical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. It was, therefore, assumed that a separate incinerator would be required for each coating line in Tennessee.

Second, it was assumed that the air flow rate to the incinerator can be reduced down to 25 percent of the Lower Explosion Limit (LEL). Reducing the air flow rate results in lower capital and fuel costs. This is possible with well-designed ovens and where product characteristics allow. However, Several paper coaters indicated that achieving 25 percent of LEL may not be possible with some coating lines, particularly older ones, or with certain types of coatings. Coating drying rate is a function of air flow rate, temperature and vapor concentration in the air. If air flow rates are to be reduced, drying temperatures or drying times must be increased. Because of the heat sensitivity of some coatings, temperature increases may not be possible. Increase in drying time will necessitate either longer ovens or reduced production rates. Several coaters of heat sensitive products indicated that, to achieve special characteristics, they could not increase emission concentrations above 5 to 6 percent of LEL and could not use oven temperatures above 140°F. Plants manufacturing conventional coated products, however, can decrease air flow rates sufficiently to increase VOC concentrations in the exhausts to 40-50 percent of LEL with only moderate increases in temperatures or changes in production rates. It has been assumed, for cost estimation purposes, that a 25 percent LEL can be attained on the average.

Third, since the number of coating lines was not known for some of the firms in Tennessee, it was estimated by using the data available for the remaining firms. This was accomplished by determining the average VOC emissions per coating line from the data available for four firms and using this average to estimate the number of lines for the remaining firms. The average emissions per coating line in Tennessee (350 tons per year) compared favorably with the average obtained for typical paper coating firms in the U.S.

Fourth, the major problem in estimating total installed costs of control systems is the cost of installation. The cost estimates given in EPA-450/2-76-028 are based on an easily retrofitted system. However, discussions with equipment manufacturers and coaters and review of published information indicated that the capital costs experienced in recent retrofit situations are three to four times higher than the EPA estimates. This issue is also addressed in EPA-450/2-76-028 which indicated that actual capital costs could be 1.5 to 3 times higher than the EPA estimates because of various retrofit difficulties. Therefore, to estimate the capital cost of control in Tennessee, the cost estimates obtained from EPA-450/2-76-028 were multiplied by a factor of three to four to account for retrofit difficulties.

Finally, the cost estimates obtained from EPA-450/2-76-028 were adjusted for inflationary increases from mid 1975, the year used in the EPA report, to mid 1977 by using an average annual inflation rate of eight percent.

The various assumptions used in estimating the costs for Tennessee are summarized in Exhibit 5-7 on the following page.

EXHIBIT 5-7
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

All of the emissions are controlled by incineration with primary heat recovery

25 percent LEL is equal to 3,000 ppm of toluene by volume.

Air flow can be reduced to reach 25 percent LEL

The price of a 2,500 SCFM system is used as an average. No costs are added for distillation or additional waste disposal.

12,008 tons of emissions are treated per year over an average operating period of 5,840 hours per year.

Other assumptions regarding incinerator and adsorber prices, as estimated in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I: Control Methods for Surface-Coating Operations, EPA-450/2-76-028, are valid.

Source: Booz, Allen & Hamilton Inc.

5.4.2 Estimated Statewide Costs

The estimated installed capital costs for retrofitting incinerators at the nine directly inpacted paper coating firms in Tennessee range from $13.7 million to $18.2 million depending upon the degree of retrofit difficulty. The corresponding annualized costs range from $3.61 million to $4.81 million of which $3.4 million to $4.6 million are annualized capital charges. The installed capital costs to individual coaters would vary from about $450,000 for one coating line to about $.5 million for 10 coating lines. The corresponding annualized costs would vary from $125,000 for one coating line to $1.25 million for ten coating lines.

5.4.3 Estimated Emission Reduction

Assuming that 90 percent of all solvents used in coating operations can be collected by properly designed hoods and ovens, emissions could be reduced by about 9,726 tons per year. This is based on a 90 percent capture and 90 percent destruction of emissions in an incinerator or 90 percent recovery in a carbon adsorption system (an overall reduction in emissions of 81 percent).

5.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of the RACT guidelines for surface coating of paper on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), and capital investment.

5.5.1 RACT Timing

Currently proposed guidelines for paper coating suggest several compliance deadlines for alternative methods of compliance.[1] Generally, for add-on systems, they call for installation of equipment and demonstration by mid-1980 or late 1980; for low solvent systems, by late 1980 or mid-1981, depending upon the degree of research and development needed. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase order to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months.
- Only a few companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements by all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

In general, it appears that if add-on control systems are used, deadlines may have to be extended based on national demand.

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[1] Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Source Categories, EPA-905/278001.

5.5.2 Technical Feasibility Issues

Incineration, which is projected to be used by the nine affected paper coating firms in Tennessee, is technically feasible, but it is not a completely satisfactory system because it requires a large amount of fuel if a good heat recovery cannot be accomplished. Similarly, carbon adsorption is feasible, but it would not be satisfactory for those coating operations that use a mixture of solvents.

Though low solvent or solventless materials are used in many paper coating operations at present, many types of solvent-based systems currently have no satisfactory replacement. In many cases, the alternative materials do not meet the product quality standards demanded by the coaters and their customers. Additional development is needed and will require the combined efforts of both the coaters (who must maintain finished product quality) and the coating material suppliers. While the time required to develop the low solvent materials is difficult to estimate, it is unlikely that new coatings can be commercialized by 1981. Ideally, the new coating materials should be adaptable to existing coating equipment to minimize additional capital investment.

5.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in annualized costs to coaters for retrofitting incinerators was estimated at $3.61 million to $4.81 million. These additional costs are projected to represent 0.8 to 1.1 percent of the total annual value of shipments of the nine Tennessee paper coating firms which bear the cost of the emission control systems. Assuming a "direct passthrough" of these costs, prices at the nine firms can be expected to increase by 0.8 to 1.1 percent.

The above estimates of price increase are based on a comparison of the cost of control with the total value of shipments by the affected firms. Since only a part of some of these firms' business represents paper coating operations impacted by the regulations, the price increase for the affected products would be higher. Such price increases would make these firms less competitive with firms not affected by similar regulations elsewhere.

The major economic impact in terms of cost to most individual companies will be the large capital expenditures required for add-on devices, rather than increased annual operating costs. For most companies, these costs would exceed their current level of capital expenditures for plant improvement and expansion. The installed capital cost for one large paper coater in Tennessee, for instance, would be about $4 million, which is substantially higher than his normal annual capital expenditure of $200,000. As a result of this financial burden this firm may have to shut down its operations. Similar financial difficulties are foreseen for marginally profitable firms which have limited capital access or for which the added annual costs of compliance are prohibitive.

5.5.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment and productivity.

The nine affected paper coating firms employ 1.4 percent of all manufacturing employees in the state. Present indication from the industry is that some of these plants may shut down because of the financial difficulties posed by the implementation of RACT, thus moderately reducing the manufacturing employment in the state.

Market structure is likely to be affected by the closure of firms with limited capital access, with their sales being absorbed by larger firms.

No significant effect on overall productivity is foreseen, except for a small change resulting from the need for add-on control system operating and maintenance personnel. This may be compensated for by small increases in productivity in firms that gain business from those who close rather than meet the RACT requirements.

5.5.5 Impact of Compliance Upon Energy Consumption

Based on the assumption that 12,008 tons per year of affected emissions would be controlled by installation of direct fire incinerators with primary heat recovery (at 35 percent efficiency), energy consumption is expected to increase by an amount equal to approximately 68,000 barrels of oil annually. This is equivalent to approximately 408 million cubic feet of natural gas annually. This increased requirement is considered to be negligible compared to current state consumption.

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Exhibit 5-8 summarizes the conclusions reached in this study and the implications of the estimated costs of compliance for paper coaters.

EXHIBIT 5-8(1)

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR PAPER COATERS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	Nine plants in the state are expected to be affected by these regulations. However, if this category were to be interpreted to include all types of paper coating, including publishing, far more firms would be affected.
Indication of relative importance of the industrial sector to the state economy	The 1977 value of shipments of these nine plants is estimated to be about $443 million. They are estimated to employ 6310 people.
Current industry technology trends	Gravure coating replacing older systems.
1977 VOC emissions (actual)	Approximately 12,008 tons per year were identified from nine plants affected. All of these are applicable under RACT.
Industry preferred method of VOC control to meet RACT guidelines	Though low solvent use is increasing, progress is slow. Add-on control systems will probably be used.
Assumed method of control to meet RACT guidelines	Thermal incineration with primary heat recovery.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $13.7 million to $18.2 milli depending on retrofit situations. This is likely to be more than 100 percent of normal expenditures for the affected paper coaters.
Annualized cost (statewide)	$3.6 million to $4.8 million annually. This represents 0.8 to 1.1 percent of the value of shipments for the nine firms directly affected.
Price	Assuming a "direct cost pass-through"-- 0.8 to 1.1 percent at the three affected firms.

EXHIBIT 5-8(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Energy	Assuming 35 percent heat recovery from the incineration system, annual energy requirements are expected to increase by approximately 68,000 equivalent barrels of oil.
Productivity	No major impact.
Employment	Moderate impact.
Market structure	Larger firms are likely to absorb sales of marginally profitable firms.
RACT timing requirements (1982)	RACT guideline needs clear definition for enforcement. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Problem areas	Retrofit situations and installation costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 2,281 tons/year (19 percent of 1977 VOC emission level from three affected plants).
Cost effectiveness of control	$370 - $493 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

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IPC Dennison, Rogersville, Tennessee
Kingsport Press, Kingsport, Tennessee
Southern Specialty Paper, Chattanooga, Tennessee
Holliston Mills, Inc., New Caxton, Tennessee
CPS Industries, Franklin, Tennessee

6.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR PLANTS SURFACE COATING FABRICS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT for plants in the State of Tennessee which are engaged in the surface coating of fabrics and vinyls.[1] This RACT category is meant to include the roll, knife or rotogravure coating and oven drying of textile fabrics (to impart strength, stability, appearance or other properties), or of vinyl coated fabrics or vinyl sheets. It includes printing on vinyl coated fabrics or vinyl sheets to modify appearance but not printing on textile fabrics for decorative or other purposes. It does not, however, include the coating of fabric substrates with vinyl plastic polymers which are usually applied as melts or plastisols that result in only minor amounts of emissions. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Alternative control methods
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of fabric coating, interviews with fabric and vinyl coaters, coating equipment and materials manufacturers, add-on control equipment manufacturers, and a review of pertinent published literature.

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[1] This analysis applies to fabric coating plants with potential emissions over 25 tons per year in Davidson, Hamilton and Shelby counties and over 100 tons per year in the rest of the state.

6.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Economic impacts

for plants in the state engaged in the surface coating of fabrics and vinyls. The quality of these estimates is discussed in the last part of this section.

6.1.1 Industry Statistics

The coating of fabrics is used to produce a large variety of common consumer and industrial products. Typical products are raincoats, upholstery, wall covering, tablecloths, window shades, gasketing, diaphragms, lifeboats and bookcovers. In most cases the finished product is manufactured by firms who purchase the coated fabric from a manufacturer whose principal activity is fabric coating. However, there are a number of vertically integrated firms (the major automobile manufacturers are typical) which both coat fabrics and manufacture finished goods from them. Other exceptions are firms which both manufacture fabrics and coat them. Thus firms which coat fabrics or vinyl coated fabrics or sheeting can be found in a number of Standard Industrial Classification categories; these are listed below:

SIC	Description
2211	Broad woven fabric mills, cotton
2221	Broad woven fabric mills, man-made and silk
2241	Narrow fabrics and other, small wares mills
2258	Warp knit fabric mills
2261	Finishers of broad woven fabrics of cotton
2262	Finishers of broad woven fabrics of man-made fiber and silk
2269	Finishers of textiles, n.e.c.*
2295	Coated fabrics, not rubberized
2297	Nonwoven fabrics
3069	Fabricated rubber products, n.e.c.*
3079	Miscellaneous plastics products
3291	Abrasive products
3293	Caskets, packing, sealing devices

*not elsewhere classified

General statistics concerning the firms included in these SIC groupings were obtained from the most recent Census of Manufactures, County Business Patterns and other economic summaries published by the U.S. Department of Commerce.

Data on industrywide shipments of coated fabrics were obtained from the Textile Economics Bureau (New York, New York). Identification of individual candidate firms which might be affected by the proposed regulation was made by review of industry directories:

- Davidson's Textile Blue Book
- Rubber Red Book
- Modern Plastic Encyclopedia
- Thomas Register of American Manufacturers
- Tennessee Directory of Manufacturers
- Membership list of the Canvas Products Association.

A list of 20 establishments expected to be affected by the proposed fabric coating RACT regulations in the state was prepared from secondary data sources and data supplied by the state and local air pollution control agencies. Approximately ten firms were interviewed by telephone and three firms were identified which have fabric coating operations affected by the proposed regulations. The other firms either had potential emissions sufficiently low not to be affected or were using exempt coating processess.

6.1.2 VOC Emissions

The state and local air pollution control agency emission inventories and information obtained during telephone interviews with the affected firms were used as a basis for estimation of the total VOC emissions from the fabric coating plants identified.

6.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from fabric coating processes are described in Control of Volatile Organic Emissions from Existing Stationary Sources, Volume II (EPA-450/2-77-008). The feasibility of applying the various control methods to fabric coating discussed in this document was reviewed with coating firms, coating suppliers, coating equipment manufacturers and industry associations. These methods include both coating reformulation and the use of control devices, such as incinerators and carbon adsorbers.

Because of the wide variety of coating processes and coating materials in use, most methods of control will find some applicability. The situations where emissions are likely to be controlled by reformulation and by control devices were estimated based on a review of the literature and on information obtained from the interviews described above.

6.1.4 Cost of Control and Estimated Reduction of VOC Emissions

The overall costs of control of VOC emissions to meet the proposed regulations were determined from:

- Generalized cost formulae based on reported emissions and judgment as to the type of control to be used
- A development of capital, operating and energy requirements for the facilities that will be affected, based on the generalized cost formulae
- Aggregation of the findings for each plant affected.

The generalized cost formulae used are to be found in:

- Control of Volatile Organic Emissions from Stationary Sources, Volume I (EPA 450/2-76-028)
- Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories.

Additional cost data were supplied by equipment and material suppliers and published literature sources. Major coaters in Tennessee, as well as in other states, were consulted to determine industry views on acceptable control methods and, in some cases, to confirm the cost estimating formulae.

6.1.5 Economic Impacts

The economic impacts were determined by: analyzing the lead time requirements to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in the state.

6.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of fabrics in the state. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are available for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgement. Exhibit 6-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 6-1
U.S. Environmental Protection Agency
DATA QUALITY--SURFACE COATING OF FABRICS

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions			X
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

6.2 INDUSTRY STATISTICS

Industry characteristics, statistics, and trends for fabric coating are presented in this section. This information forms the basis for assessing the total impact of implementing RACT for control of VOC emissions in this category upon the state economy and upon the individual firms concerned.

6.2.1 Size of the Industry

The Bureau of Census, in 1976 County Business Patterns, reported a total of about 23 plants in SIC categories in which plants coating fabrics in the non-attainment counties in Tennessee would be expected to be tabulated. Pertinent data concerning these plants are summarized in Exhibit 6-2, on the following page. As mentioned earlier, based on data provided by the state and local air pollution control agencies and Booz, Allen interviews, only three plants were found to be affected by the proposed regulations and are listed in Exhibit 6-3, following Exhibit 6-2.

As shown, these three affected firms are estimated to employ a total of about 285 people. The total annual value of shipments of the three firms is estimated at $20.2 million based on an average of $71,000 per employee, which is characteristic of firms in SIC 2295, fabric coating.

6.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of these plants with the state economy indicates that these plants represent a small percentage of the total value of shipments by manufacturing plants and employ about 0.6 percent of the manufacturing workers in the state.

6.2.3 Historical and Future Patterns of the Industry

The fabric coating industry in the U.S., except for the general economic slump in 1975, has shown a gradual but steady growth in sales and shipments over the last several years as demonstrated by Exhibits 6-4 and 6-5, on the following pages. The largest growth in terms of dollar value of shipments was for vinyl coated fabrics

EXHIBIT 6-2

U.S. Environmental Protection Agency

INDUSTRY STATISTICS FOR PLANTS IN SIC CATEGORIES WHERE FABRIC COATING MAY BE USED IN TENNESSEE

SIC	Name	Number of Firms[a]	Number of Employees[a]	Estimated Value of Shipments[b] ($Million)	Estimated New Expenditures[b] ($Million)
2211	Broad woven fabrics mills, cotton	15	3,330	116	3.9
2221	Broad woven fabric mills, man-made and silk	9	3,446	129	5.4
2241	Narrow fabrics and other, small wares mills	6	397	13	0.2
2258	Warp knit fabric mills	2	203	13	0.4
2261	Finishers of broad woven fabrics of cotton	10	1,056	35	1.1
2262	Finishers of broad woven fabrics of man-made fiber and silk	4	2,416	145	5.4
2269	Finishers of textiles, n.e.c.	5	250	13	0.2
2295	Coated fabrics, not rubberized	6	607	43	0.9
2297	Nonwoven fabrics	1	2	0.1	-
3069	Fabricated rubber products, n.e.c.	34	4,108	176	6.7
3079	Miscellaneous plastics products	130	9,777	486	23
3291	Abrasive products	6	255	8	0.5
3293	Gaskets, packing, sealing devices	4	374	14	0.5
		232	26,221	1,191	48.2

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a. Tennessee Department of Economic and Community Development, Tennessee Directory of Manufacturers, 1978.

b. Booz, Allen estimate based on average value of shipments and new expenditures per employee from 1976 Annual Survey of Manufactures, U.S. Department of Commerce, adjusted to 1977.

Source: Booz, Allen and Hamilton Inc.

EXHIBIT 6-3
U.S. Environmental Protection Agency
FIRMS EXPECTED TO BE AFFECTED BY THE FABRIC COATING RACT REGULATIONS IN TENNESSEE

Firm	Location	Employees	Activity
Americo Inc.	Memphis	20	Laminating, vinyl printing
Fields Plastic & Chemicals	Cleveland	75	Laminating, vinyl printing
Quimet Corporation	Nashville	190	Vinyl coating and printing

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 6-4
U.S. Environmental Protection Agency
U.S. ANNUAL VALUE OF SHIPMENTS OF COATED FABRICS
($ millions)

Item	1972	1973	1974	1975	1976
Pyroxylin-Coated Fabrics	876.5	693.7	728.7	681.5	817.4
Pyroxylin-Coated Fabrics	26.3	27.3	34.5	28.0	32.5
Vinyl Coated Fabrics	601.9	693.7	728.7	681.5	817.4
Other Coated Fabrics	154.1	188.0	212.6	202.7	213.8
Coated Fabrics, not rubberized	26.3	27.4	(13.6)[a]	(1.4)[a]	(33.8)[a]
Rubber Coated Fabrics	67.9	73.6[b]	83.5[b]	72.0[b]	80.0[b]
TOTAL	876.5	1,011.9	1,156.5	985.6	1,177.5

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a. Values obtained by difference from gross shipments of all coated fabrics, not rubberized.

b. Booz, Allen estimate based on shipments of "Other Rubber Goods, N.E.C.", SIC Code 30698

Source: 1976 Annual Survey of Manufactures

EXHIBIT 6-5
U.S. Environmental Protection Agency
U.S. ANNUAL SHIPMENTS OF BACKING MATERIALS FOR COATED FABRICS
(in millions of pounds)

	1972	1973	1974	1975	1976
Transportation Fabric, all fibers[a]	95.4	100.9	64.6	65.3	81.5
Coated and Protective Fabrics[b]	133.7	149.3	167.5	137.8	177.6
TOTAL	229.1	250.2	232.2	203.1	259.1

Notes:

a. Transportation fabric includes auto seat upholstery and slipcovers, sidewall, headlining and sheeting. The cotton poundage include the knit and woven fabric used as the backing for vinyl sheeting. The item includes convertible auto tops & replacements thereof, as well as upholstery used in other kinds of transportation, such as airplanes, railroad & subway cars, buses, etc. It does not include seat padding, transportation rugs, window channeling flocking, tassels, trim, etc., or the textile glass fiber used in reinforced plastic seating for subways, buses, etc.

b. Coated and protective fabrics includes parachutes, deceleration chutes and tow targets; awning; beach, garden & tractor umbrellas; inflatable dunnage and cushions, air-supported structures and automotive air-spring diaphragms; boat and pool covers; tarpaulin covers for athletic fields, etc.; also, the substrates used for vinyl sheeting. The cotton poundage include awnings, boat covers, tarpaulins and tents. Not included here are the cotton poundages used for vinyl substrates. Such poundages are tabulated with their appropriate end use, i.e., transportation upholstery, upholstery etc. Does not include man-made fiber surfaces for recreational fields.

Source: Textile Economics Bureau, Technicon, November 1977 which increased by $215.5 million in shipments from 1972 to 1976, compared with an increase of $301 million for all coated fabrics. Pyroxylin (cellulose nitrate) coatings, because of their low cost and ease of application, still continue to occupy a steady though proportionately smaller share of the market. Natural and artificial rubber coated fabrics, because of unique properties not obtainable with plastic materials, also maintain a substantial (about 10 percent) share of the coated fabric market. Vinyl and urethane coatings, however, are replacing a larger share of both markets.

6.3 TECHNICAL SITUATION IN THE INDUSTRY

This section describes the principal materials and processes used in fabric and vinyl coating and various methods which are considered to be reasonably available control technology to meet proposed regulations. The proposed RACT guidelines for fabric coating and an estimate of the total VOC emission reduction possible if the guidelines are implemented in the state are also presented.

6.3.1 General Coating Process Description

Fabrics are coated primarily to render them resistant to penetration by various fluids or gases, improve abrasion resistance or modify the appearance or texture. Typical examples are materials used in shower curtains; rubber life rafts; balloons; drapery material; synthetic leathers for shoes, upholstery or luggage; table cloths; and outdoor clothing. The base fabrics can be asbestos fiber cloth, burlap and pile, cotton drill, duck canvas, glass fabrics, knit cotton or rayon, nonwoven fabrics or nylon sheeting. In the case of coating of vinyls, the substrate is a flexible vinyl sheet or cloth-supported vinyl on which a coating is applied to enhance the appearance or durability of the vinyl surface.

Typical coating materials are rubber compounds, vinyl resins of various types, polyesters, polyurethanes, nitrocellulose resins, oleo resins, phenolic resins, epoxy resins and polyethylene. Various techniques are used for applying these coatings as melts, plastisols, latexes, solutions or other forms. The proposed guidelines are primarily concerned with coatings applied as solutions, where large volumes of volatile organic materials can be emitted. Descriptions of the processes for coating with coating materials dissolved in organic solvents may be found in the EPA guideline series Control of Volatile Organic Emissions from Stationary Sources Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light Duty Trucks, EPA-450/2-77-008, May 1977.

6.3.2 Emissions and Current Controls

The reported and potential VOC emissions from the three plants likely to be affected by RACT guidelines in the state are summarized in Exhibit 6-6 on the following page.

EXHIBIT 6-6
U.S. Environmental Protection Agency
REPORTED AND POTENTIAL EMISSIONS

Firm	Location	Actual Emissions (tons/yr)	Estimated Potential Emissions[a] (tons/yr)
Americo, Inc[b]	Memphis	9.0	39
Fields Plastics & Chemicals[c]	Cleveland	61.5	257
Quimet Corporation[d]	Nashville	70.0	306
		140.5	602

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a. Based on 8760 hours per year operation

b. Booz, Allen estimate based on interview with plant personnel

c. Data supplied by the state

d. Actual emissions suppled by the state, potential emissions estimated by Booz, Allen.

Source: Booz, Allen & Hamilton Inc.

The total actual VOC emissions from fabric coating lines in these plants were 140.5 tons in 1977. No controls are now used by these plants.

6.3.3 RACT Guidelines

The RACT guidelines for control of VOC emissions from fabric coating require that emissions from coating lines be limited to a level of 2.9 pounds per gallon of coating for coating of fabric substrates and 3.8 pounds per gallon for coating of vinyl substrates. Both limits are based upon the use of an add-on device which recovers or destroys 81 percent of the VOC introduced in the coating. This the U.S. EPA considers to be achievable by capture of 90 percent of the VOC emissions and destruction of these emissions in an add-on device such as an incinerator. In some cases use of alternative low solvent or solventless coatings can also be used to meet these limits.

6.4 ALTERNATIVE CONTROL METHODS

In this section are briefly discussed methods of low solvent and solventless systems which have been demonstrated to be applicable to some fabric coating products, and the two principal add-on systems, incineration and carbon adsorption, generally used for emission control. This information has been extracted principally from the previously cited EPA report, Control of Volatile Organic Emissions from Existing Sources, Volumes I and II, which should be consulted for a more thorough discussion. In some instances, additional comment was obtained from coaters, coating material suppliers and control equipment manufacturers.

6.4.1 Low Solvent and Solventless Coatings

Organic emissions can be reduced 80 to 100 percent through use of coatings which inherently have low levels of organic solvents. Both high-solids and waterborne coatings are used. The actual reduction achievable depends on the organic solvent contents of the original coating and the new one. Using a coating which has a low organic solvent content may preclude the need for an emission control device. Often the coating equipment and procedures need not be changed when a plant converts to coatings low in organic solvent.

Although a number of companies have converted to low solvent coating, either in part or in total, one may not presume them to be universally applicable. Each coating line is somewhat unique and many coated fabrics have different specifications.

None of the plants identified were aware of suitable alternative coatings currently available which would meet the quality and performance standards required in all of their products. Some firms in the U.S. have over the last several years converted to waterborne coatings on some products and believe that if sufficient time were allowed for research and development a majority of their coatings could be replaced by low solvent ones. There may be some coatings which could not be replaced.

6.4.2 Incineration

Catalytic and direct thermal incineration processes convert hydrocarbons to carbon dioxide and water at high temperatures. Incineration is widely accepted as a reliable means of reducing hydrocarbon emissions by 90 percent or more.

Generally, the major disadvantage of this approach is the increased energy required to raise the exhaust gas temperatures over 1,200°F for direct incineration and 700°F for catalytic incineration. Natural gas is the most commonly used fuel though propane, fuel oils, or other fluid hydrocarbons can be employed. Fuel oil is not generally acceptable because of the sulfur oxides generated in combustion or the presence of catalyst poisons in the oil. Another problem is the generation of nitrogen oxides in direct fired incinerators resulting from the exposure of air to high-temperature flames.

The increased energy consumption can, in some cases, be reduced or eliminated by heat exchange of the exhaust gases with fresh emissions (primary heat recovery) or by use of the hot exhaust gases in process applications (secondary heat recovery). Typical use of secondary heat recovery is for oven heat in drying or curing ovens. In fact, with efficient primary exchange and secondary heat recovery, total fuel consumption of an incinerator-oven system can be less than that for the oven before the incinerator is added. The heat required to sustain the system comes from combustion of volatile organic compounds in the exhausts.

Both catalytic and direct fired systems are capable of high heat recovery efficiency if several conditions occur:

- VOC concentrations are or can be increased to 8-10 percent or more of their LEL (lower explosion limit).
- Oven temperatures are sufficently high to enable use of the sensible heat in the exhaust gases after primary heat exchange. Usually, oven temperatures above 140°F are sufficient to allow 85 percent or more overall heat recovery.
- Where catalytic incinerators are used, no compounds must be present in the gases treated which could poison or blind the catalyst.

In most coating operations, drying and curing temperatures are 250°F or higher. By reduction of air flow to reach exhaust levels of 8-10 percent or higher and proper design of the heat recovery system, it may be possible to achieve overall heat recoveries of 85 percent or greater.

6.4.3 Carbon Adsorption

Carbon adsorption has been used since the 1930s for collecting solvents emitted from paper coating operations. Most operational systems on coating lines were installed because they were profitable. Pollution control has usually been a minor concern. Carbon adsorption systems on coating lines range in size from a few thousand to tens of thousands of cubic feet per minute. Exhausts from several coating lines are often manifolded together to permit one carbon adsorption unit to serve several coating lines.

The greatest obstacle to the economical use of carbon adsorption is that, in some cases, reusing solvent may be difficult. In many coating formulations, a mixture of several solvents is needed to attain the desired solvency and evaporation rates. If this solvent mixture is recovered, it sometimes cannot be reused in formulating new batches of coatings. Also if different coating lines within the plant use different solvents and are all ducted to one carbon adsorption system, then there may be difficulty reusing the collected solvent mixture. In this case, solvents must be separated by distillation.

However, in some cases azeotropic, constant boiling, mixtures can occur which can be separated only by specialized techniques. Most coating firms would not have the skills necessary for the complex distillation and separation procedures needed. For small adsorption systems, the additional separation expenses would probably exceed the cost of fresh solvent.

Also, adsorption of solvents containing water soluble compounds (such as alcohols, ketones or esters) can present a secondary pollution problem where steam is used for bed regeneration. Additional treatment of the condensed steam with its content of dissolved organics would be required, increasing the complexity of the solvent recovery system and its cost.

6.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section discusses the projected costs of control for fabric coating in the non-attainment areas of the state based on the emissions as discussed in Section 6.3.4 of this report. Where possible, the validity of the costs was confirmed with coating firms and equipment manufacturers.

The coaters interviewed in Tennessee indicated incineration as the most likely control method to comply with RACT guidelines.

6.5.1 Costs of Alternative Control Systems

Exhibit 6-7, on the following page, summarizes costs for a typical incineration system as developed by EPA sources. These costs are based on the assumption that exhaust flow rates can be reduced sufficiently to obtain LEL levels of 25 percent. This is possible with well-designed capture systems where intake air flows can be reduced or where product characteristics allow. Lower LEL levels require higher air flow and thus result in higher control costs.

Incinerator costs are a function of equipment size, which varies generally with air flow rate. In the three affected plants it would be practical to manifold exhausts so that all exhausts could be treated in one add-on emission control system. Also, it would be difficult to use secondary heat recovery on ovens where the incinerator is remote from the oven.

The major problem in estimating total installed costs of control systems is the added cost of installation. The estimates in Exhibit 6-7 were made based on commonly experienced retrofitting difficulties and are three to four times the EPA estimates given in EPA-450/2-76-028.

6.5.2 Estimated Statewide Costs

The total emissions considered to be applicable under RACT, as discussed in Section 6.3.4 of this report, are about 140 tons per year for the three potentially affected firms. The firms have not decided on possible control options, but are likely to select the incineration method for compliance with the proposed regulations.

EXHIBIT 6-7
U.S. Environmental Protection Agency
INCINERATION COSTS FOR A TYPICAL FABRIC COATING LINE[a]

Incineration Device	Installed Cost ($)	Annualized Cost ($/yr.)	Control Cost[b,c] ($/ton of solvents recovered)
No heat recovery			
Catalytic	315,000	88,000	890
Noncatalytic (Afterburner)	298,000	92,000	920
Primary heat recovery			
Catalytic	402,500	102,000	1,020
Noncatalytic	385,000	100,000	1,000

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a. These costs are based on an air emission flow rate of 2,000 SCFM for a 25 percent LEL volatile organic content; oven temperature of 300°F and operating time of 2,000 hours per year. Other assumptions are as tabulated in EPA-450/2-76-028, Table 4-3 except capital costs are multiplied by 3.5 to account for common retrofit situations which may include modifications to improve collection system.

b. In Tennessee plants are expected to require installation of incinerators for air flows from 200 to 16,000 SCFM. Use of smaller sized incinerators results in a higher $/ton control costs; larger incinerators will have a lower $/ton control cost.

c. These control costs in terms of $/ton as presented in Control of Volatile Organic Emissions from Existing Stationary Sources. Volume II, EPA-450/2-77-008 are about 1/20 of these values becasue of lower capital charges and use of the costs of a larger sized incinerator. This difference illustrates the misleading results of applying $/ton as a parameter in evaluating costs when different sizes of incinerators are used.

Source: Booz, Allen & Hamilton, Inc. revisions of data in EPA-450/2-76-028

Total costs of compliance were therefore based on 140 tons per year of emissions being treated by incineration.

For incineration costs, the capital and annualized costs presented in Control of Volatile Organic Emissions from Existing Stationary Sources, Vol. I (EPA-450/2-76-028) were used. This report projects estimated costs for the control system as a function of total air flow rate.

The air flow rate for the affected firms was determined on the assumption of a 25 percent approach to LEL, other assumptions summarized in Exhibit 6-8 on the following page, and the firm's current estimated emissions. These air flow rates were then used to estimate costs from EPA-450/2-76-028.

By applying these cost estimating procedures, capital costs for incineration were estimated to be $316,000 with annualized costs of $91,000, of which $79,000 is capital charges. Both are adjusted for inflationary increases from mid-1975 (base period for EPA-450/2-76-028 data) to mid-1977 by using an average inflation rate of 8 percent per year.

However, discussions with equipment manufacturers and coaters and review of published information indicated that these capital costs estimates are probably three to four times lower than those experienced in recent retrofit situations. This issue is also addressed in EPA-450/2-76-028 which indicated that baseline capital costs estimates could be 1.5 to 3 times lower than actual costs because of various retrofit difficulties.

Therefore, using multipliers of three and four it is estimated that actual capital costs in the state are more likely to range from $0.95 million to $1.3 million with corresponding annualized costs of $249,000 to $328,000.

The capital costs for individual firms are estimated to vary from $290,000 to $330,000 for a multiplier of 3 and from $380,000 to $450,000 for a multiplier of 4. The corresponding annualized costs would vary from $75,000 to $88,000 for the multiplier of 3 and from $99,000 to $115,000 for the multiplier of 4.

EXHIBIT 6-8
U.S. Environmental Protection Agency
SUMMARY OF ASSUMPTIONS USED IN COST ESTIMATE

Assumptions

90 percent of emissions are controlled by incineration with primary heat recovery; 90 percent of solvent emissions from the coating line are collected. Total reduction is 81 percent.

Air flow can be reduced to reach 25 percent LEL

Emission rate is constant over a period of 5,840 hours per year.

Other assumptions regarding incinerator prices and operating parameters,as estimated in *Control of Volatile Organic Emissions from Existing Stationary Sources*, *Vol. I: Control Methods for Surface-Coating Operations*, EPA-450/2-76-028, are valid.

Source: Booz, Allen & Hamilton Inc.

6.5.3 Estimated Emission Reduction

Assuming that 90 percent of all solvents used in coating operations can be collected by properly designed hoods and ovens, emissions could be reduced by about 114 tons per year. This is based on a 90 percent reduction of emissions in an incinerator (an overall reduction in emissions of 81 percent). This reducton represents 81 percent of those emissions affected by RACT (emissions from the three affected firms).

6.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic implications of the RACT guidelines for surface coating of fabrics on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; impact on economic indicators, such as value of shipments, unit price (assuming full cost pass-through), state economic variables and capital investment; and impact on energy consumption.

6.6.1 RACT Timing

Currently proposed regulations for fabric coating in Tennessee suggest three sets of compliance deadlines for alternative methods of compliance.[1] For add-on systems, they call for installation of equipment and demonstration by November 1, 1981 and for low solvent systems, by September 1, 1981. Major coaters, material suppliers and equipment manufacturers believe these deadlines to be unattainable.

- Normally, large incinerator and carbon adsorption systems will require about a year or more from receipt of purchase order to install and start up the system. Engineering may require three months or more, fabrication three to six months and installation and startup as long as three months. A major web coater with considerable experience with similar installations estimates that the complete cycle of installation, from initial selection of control method to testing of the system, would require 37 months plus an initial 13 months to establish an economically sound method of control.

- Only a small number of companies manufacture incineration systems with proven high heat recovery. The cumulative effect of equipment requirements of all firms in the U.S. needing control devices could severely impede the ability of these firms to supply equipment. In some cases, the most efficient devices are only now undergoing initial trials, and no production capacity has been developed.

- A major coating firm estimates that the use of low solvent or solventless coatings may take as long as 68 months from initial research, through product evaluation and customer acceptance to final production. Product and process development alone may take as long as 24 months and product evaluation over 14 months.

In general, it appears that if either add-on control systems are used or new low solvent systems need to be developed, deadlines may need to be extended.

6.6.2 Technical Feasibility Issues

Although incineration was identified as the most likely control alternative in Tennessee, as discussed above, incineration is not a completely satisfactory add-on control system. Incineration requires large volumes of additional fuel if good heat recovery is not achieved.

6.6.3 Comparison of Costs with Selected Economic Indicators

The net increase in annualized operating costs to coaters to install and operate incinerators was estimated at $249,000 to $328,000. These additional costs are projected to represent 1.2 percent to 1.6 percent of the total annual value of shipments of the firms affected by the proposed regulations. Assuming a "direct passthrough" of these costs, prices can be expected to increase by about the same fraction.

The major economic impact in terms of cost to individual companies will probably be capital related rather than due to increased annual operating costs. The projected capital expenditure of $300,000 to $450,000 is several times the normal annual capital expenditure of the affected firms and may severely affect the smaller firms.

6.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Total employment in the state is not expected to be significantly affected since only about 300 workers are employed in coating operations in the plants that may be affected by the regulation.

Market structure is not expected to be affected by the proposed regulations. Productivity is not expected to be affected except for a short period when lines must be shut down for modifications or installation of equipment.

6.6.5 Impact of Compliance Upon Energy Consumpton

Based on the assumption that the affected emissions would be controlled by installation of direct fired incinerators with primary heat recovery only (at 35 percent efficiency), energy consumption is expected to increase by an amount equal to about 970 barrels of oil annually. The estimate is based further on the assumption that oven exhausts are about 300°F, and that a barrel of oil is equivalent to 6.0 x 10^6 BTUs. This increased requirement is considered to be negligible compared to current state consumption.

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Exhibit 6-9, on the following page, summarizes the conclusions and projected implications of the results from this study.

EXHIBIT 6-9(1)

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR FABRIC COATERS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	Three plants in the state's non-attainment areas are expected to be affected by these regulations.
Indication of relative importance of industrial sector to the state economy	The 1977 value of shipments of these plants is estimated to be about $20.2 million. They are estimated to employ 300 people in fabric coating operations.
Current industry technology trends	Newer plants are built with integrated coating and emission control systems; older plants are only marginally competitive now.
1977 VOC emissions (actual)	Current emissions are estimated at about 140 tons/year.
Industry preferred method of VOC control to meet RACT guidelines	Not yet decided
Assumed method of VOC control to meet RACT guidelines	Direct fired incineration with primary heat recovery.

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	Estimated to be $0.9 million to $1.2 million depending on retrofit situations.
Annualized cost (statewide)	$250,000 to $330,000 annually.
Price	Assuming a "direct cost pass-through"--1.2 to 1.6 percent.
Energy	Assuming 35 percent heat recovery, annual energy requirements are expected to increase by approximately 970 equivalent barrels of oil.
Productivity	No major impact.
Employment	No major impact.
Market structure	No major impact.

EXHIBIT 6-9(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
RACT timing requirements (1982)	RACT guidelines need clear definition for rule making. Equipment deliverables and installation of incineration systems prior to 1982 are expected to present problems. Development of low solvent systems is likely to extend beyond 1982.
Problem areas	Retrofit situations and installation costs are highly variable. Type and cost of control depend on particular solvent systems used and reduction in air flow.
VOC emissions after control	Approximately 36 tons/year (19 percent of 1977 VOC emission level from affected plants).
Cost effectiveness of control	$2,200 to $2,900 annualized cost/annual ton of VOC reduction.

Source: Booz, Allen & Hamilton Inc.

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8.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SURFACE COATING OF METAL FURNITURE IN THE STATE OF TENNESSEE

This chapter presents a detailed economic analysis of implementing RACT controls for surface coating of metal furniture in the State of Tennessee. The chapter is divided into six sections:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of metal furniture plants, interviews with industry representatives and analysis of findings.

8.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for estimating:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for surface coating of metal furniture in Tennessee.

The quality of the estimates is described in detail in the last part of this section.

8.1.1 Industry Statistics

Industry statistics on metal furniture manufacturing plants were obtained from several sources. All data were converted to a base year 1977, based on specific scaling factors. The number of establishments for 1977 was based on the Tennessee Directory of Manufacturers supplemented by a review of the 1976 County Business Patterns, and verified and refined by interviews wth potentially affected metal furniture manufacturing corporations. The number of employees was obtained from the Tennessee Directory of Manufacturers and refined during interviews with potentially affected metal furniture manufacturers.

The industry value of shipments was estimated by using the value of shipments given in the 1972 Census of Manufactures for SIC Codes 2514, 2522, 2531 and 2542 and scaled to 1977 assuming a 6 percent linear rate of growth. The ratio of value of shipments to number of employees is equivalent to approximately $32,000 per employee, compared with approximately $40,000 per employee in metal furniture manfacturing nationwide. All of the employees are assumed to be involved in the metal furniture manufacturing operations.

8.1.2 VOC Emissions

The VOC emissions were obtained from the State Emissions Inventory for the rural unclassified counties and from the regional air pollution control offices for the three non-attainment areas of the state. These emissions were verified and refined during telephone interviews with potentiallly affected firms.

8.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for metal furniture plants are described in Control of Volatile Organic Emissions from Stationary Sources, EPA-450/2-77-032. The data provide the alternatives available for controlling VOC emissions from metal furniture manufacturing plants. Several studies of VOC emission control were also analyzed in detail, and metal furniture manufacturers were interviewed to ascertain the most likely types of control techniques to be used in metal furniture manufacturing plants in Tennessee. The specific studies analyzed were Air Pollution Control Engineering and Cost Study of General Surface Coating Industry, Second Interim Report, Springborn Laboratories, and informational literature supplied by the metal furniture manufacturers.

8.1.4 Cost of Controlling VOC Emissions for Surface Coating of Metal Furniture

The costs of control of volatile organic emissions for surface coating of metal furniture were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining equipment components
- Developing installed capital costs for modifications of existing systems
- Aggregating installed capital costs for each alternative control system
- Defining two model plants
- Developing costs of a control system for the model plants:
    - Installed capital cost
    - Direct operating cost
    - Annual capital charges
    - Energy requirements
- Extrapolating model costs to individual industry sectors

- Aggregating costs to the total industry for the state.

The model plants used as the basis for estimating the costs of meeting RACT were solvent-based dipping and solvent based electrostatic spraying operations. the cost of modifications to handle waterborne or high solids coatings was not considered to be a function of the type of metal furniture to be coated, since no modifications to the production lines are necessary. Modifications are required only to the coatings handling and pumping and spraying equipment, and these would not differ for different types of furniture pieces.

8.1.5. Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Tennessee.

8.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of metal furniture in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 8-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 8-1
U.S. Environmental Protection Agency
SURFACE COATING OF METAL FURNITURE
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X	X	
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

8.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for metal furniture manufacturing plants in Tennessee are presented in this section. Data in this section form the basis for assessing the economic impact of implementing RACT for control of VOC emissions from metal furniture manufacturing plants in the state.

8.2.1. Industry Characteristics

Metal furniture is manufactured for both indoor and outdoor use and may be divided into two general categories: office or business and institutional, and household. Business and institutional furniture is manufactured for use in hospitals, schools, athletic stadiums, restaurants, laboratories and other types of institutions, and government and private offices. Household metal furniture is manufactured for home and some general office use.

8.2.2 Size of the Industry

Booz, Allen, through interviews and the State Emissions Inventory, has identified eight facilities participating in the manufacture and coating of metal furniture that are currently potentially affected by RACT guidelines. One of these firms, Metals Engineering Corporation, plans to convert all of its metal furniture coating operations to high solids this year for economic reasons. This conversion will take place whether or not the proposed regulations take effect. Of the remaining seven industries, two will be impacted by the 25 ton per year standard and five will be impacted by the 100 ton per year standard. The names and locations of the industries are listed in Exhibit 8-2, on the following page. These seven facilities accounted for an estimated $58 million in metal furniture shipments in 1977. This is equivalent to about 1.8 percent of the U.S. value of shipments of metal furniture. The total number of employees in these seven metal furniture manufacturing facilities in Tennessee is approximately 1,800.

8.2.3 Comparison of the Industry to the State Economy

A comparison of the value of shipments of metal furniture with the state economy indicates that the metal furniture industry represents about 0.44 percent

EXHIBIT 8-2
U.S. Environmental Protection Agency
LIST OF MANUFACTURERS POTENTIALLY AFFECTED BY RACT GUIDELINES FOR SURFACE COATING OF METAL FURNITURE IN TENNESSEE

Facility Name	Location
G.F. Business Furniture	Gallatin
Globe Business Furniture	Andersonville
Massey Seating	Nashville
Sampsonite Corporation	Murfreesboro
Sandusky-Memphis	Memphis
Tenneco	Dickson
Tennessee State Industries (State Prison)	Nashville

Source: Tennessee Emissions Inventory and Booz, Allen & Hamilton Inc. interviews.

of the total Tennessee value of shipments of all manufactured goods and the seven affected facilities represent approximately 0.23 percent. The industry employs approximately 0.7 percent of all people employed in manufacturing in Tennessee, and the seven affected facilities employ approximately 0.37 percent.

The Tennessee State Industries facility in Nashville accounts for approximately 2 percent of the total VOC emissions from potentially affected metal furniture coating facilities in Tennessee. Therefore, its inclusion or omission from the analysis would not substantially affect the predicted economic impact of implementing RACT guidelines.

8.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on metal furniture manufacturing operations, estimated VOC emissions, the extent of current control and the likely alternatives which may be used for controlling VOC emissions in Tennessee.

8.3.1 Metal Furniture Manufacturing and Coating Operation

Manufacturing of metal furniture consists of the following steps: fabrication of furniture parts, coating and final assembly. Coating operations usually include surface preparation, coating and curing. These operations are discussed in detail in the EPA guideline series Control of Volatile Organic Emmissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

8.3.2. Emissions and Current Controls

This section presents the estimated VOC emissions from metal furniture manufacturing facilities in Tennessee in 1977 and the current level of emission controls implemented in the state. Exhibit 8-3, on the following page, shows the total emissions from the seven metal furniture manufacturing facilities to be about 950 tons per year.[1] These emissions were obtained from the State Emissions Inventory and from the regional air pollution control offices in Tennessee and verified and refined during telephone interviews with affected facilities.

Experiments with water based coatings by several manufacturers who currently use solvent based electrostatic spray coating lines have not provided the quality of finish or the production line speed desired. One manufacturer is experimenting with high solids coatings, and is currently using 60 percent solids in approximately 10 to 15 percent of his operation.

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[1] One additional manufacturer with current VOC emissions of approximately 440 tons per year plans to convert all coating operations to high solids by December 31, 1979 and therefore is assumed not to be affected by RACT.

EXHIBIT 8-3
U.S. Environmental Protection Agency
SUMMARY OF HYDROCARBON EMISSIONS FROM METAL FURNITURE MANUFACTURING FACILITIES IN TENNESSEE

Facility Name	No. of Sources	Hydrocarbon Emissions (Tons/Year) Current	Potential
G.F. Business Furniture[a]	1	300	1,314
Globe Business Furniture[a]	1	183	732
Massey Seating[a]	1	9	39
Samsonite Corporation[b]	2	182	1,144
Sandusky-Memphis[b]	1	68	298
Tenneco[b]	2	193	1,035
Tennessee State Industries[a]	1	18	78

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a. Booz, Allen estimate based on data provided during industry interviews.

b. Data from Tennessee Emissions Inventory.

Source: Tennessee Emissions Inventory and Booz, Allen & Hamilton Inc. interviews.

8.3.3 RACT Guidelines and Control Options

The emission limitations that can be achieved through the application of Reasonably Available Control Technology (RACT) for the metal furniture coating industry are presented in Exhibit 8-4, on the following page. This emission limit is based on the use of low organic solvent coatings. It can also be achieved with waterborne coatings and is approximately equivalent (on the basis of solids applied) to the use of an add-on control device that collects or destroys about 80 percent of the solvent from a conventional high organic solvent coating. Greater reductions (up to 90 percent) can be achieved by installing new equipment which uses powder or electrodeposited waterborne coatings. A comparison of the various control options is presented in Exhibit 8-5, following Exhibit 8-4.

8.3.4 Selection of the Most Likely RACT Alternatives

The choice of application of control alternatives for the reduction of hydrocarbon emissions in existing facilities for the surface coating of metal furniture requires a line-by-line evaluation. A number of factors must be considered, based on the individual characteristics of the coating line to be controlled. The degree of economic dislocation is a function of these factors.

The first factor to be considered is whether the existing equipment can be used by the substitution of a coating material which will meet the RACT guideline. This alternative would require the least capital expenditure and may minimize production downtime.

If the existing equipment has to be modified, replaced or expanded, factors to consider are the kind of changes that have to be made, the capital costs, the change in operating costs, the length of time needed to make the changes, the effect on the production rate, the operational problems that will have to be handled and the effect on the quality of the product.

Interviews with industry representatives indicate that several of the affected manufacturers will use their existing spraying equipment and modify it to handle high solids coatings. The reasons given for this preference are that a high quality finish is required.

EXHIBIT 8-4
U.S. Environmental Protection Agency
EMISSION LIMITATIONS FOR RACT IN SURFACE COATING OF METAL FURNITURE

	Recommended Limitation	
Affected Facility	kg of organic solvent emitted per liter of coating (minus water)	lbs. of organic solvent emitted per gallon of coating (minus water)
Metal furniture coating line	0.36	3.0

Source: Control of Volatile Organic Emissions from Existing Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

EXHIBIT 8-5(1)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne electrodeposition (EDP)	Primecoat or single coat	90-95[a]	Provides excellent coverage, corrosion protection and resistance Fire hazards and potential toxicity are reduced Dry off oven may be omitted after cleansing if an iron-phosphate pretreatment is used Good quality control due to fully automated process may be offset by increased electrical requirements for the coating, refrigeration and circulation systems if EDP replaces waterborne flow or dip coating operations. This would not be true if EDP replaces a spraying operation EDP can be expensive on small-scale production lines

EXHIBIT 8-5(2)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (spray dip or flow coat)	All applications	60-90[a]	This will likely be the first option considered because of the possibility that these coatings can be applied essentially with existing equipment
			Requires a longer flash-off area than organic solvent-borne coatings
			Curing waterborne coatings may allow a decrease in oven temperature and some reduction in airflow, but limited reduction if high humidity conditions occur
			Spraying electrostatically requires electrical isolation of the entire system. Large lines may be difficult to convert because coating storage areas may be hundreds or thousands of feet away from the application area

EXHIBIT 8-5(3)

U.S. Environmental Protection Agency

RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Waterborne (spray dip or flow coat) (continued)			Dip or flow coating application requires closer monitoring due to its sensitive chemistry
			Weather conditions affect the application, so flash-off time, temperature, air circulation and humidity must be frequently monitored
			Changes in the number of nozzels may be required
			Sludge handling may be more difficult
Powder (spray or dip)	Top or single coat	95-99[a]	No solid or liquid wastes to dispose of
			Powder may reduce energy requirements in a spray booth and the ovens because less air is required than for solvent-borne coatings and flash-off tunnel is eliminated

EXHIBIT 8-5(4)

U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Powder (spray or dip) (continued)			Powder can be reclaimed, resulting in up to 98% coating efficiency All equipment (spray booths, associated equipment and often ovens) used for liquid systems must be replaced Powder films cannot be applied in thicknesses of less than 2 mils and have appearance limitations Powder coatings may be subject to explosions Excessive downtime (half-hour) is required during color changes. If powders are not reclaimed in their respective colors, coating usage efficiency drops to 50% to 60%
High solids (spray)	Top or single coat	50-80[a]	May be applied with existing equipment

EXHIBIT 8-5(5)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
High solid (spray) (continued)			Reduces energy consumption becasue it requires less airflow in the spray booth, oven and flash-off tunnel Potential health hazard associated with isocyanates used in some high-solid two-component systems
Carbon adsorption	Prime, single or top coat (application and flash-off areas)	90[b]	Although it is technically feasible, no metal furniture facilities are known to use carbon adsorption Additional energy requirement is a possible disadvantage Additional filtration and scrubbing of emissions from spray booths may be required There is little possibility or reusing recovered solvents because of the variety of solvent mixtures

EXHIBIT 8-5(6)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Carbon adsorption (continued)			Many facilities may require dual-bed units which require valuable plant space Particulate and condensable matter from volatilization and/or degradation of resin, occurring in baking ovens with high temperature, could coat a carbon bed
Incineration	Prime, single or topcoat (ovens)	90^b	These are less costly and more efficient than carbon adsorbers for the baking ovens because the oven exhaust temperatures are too high for adsorption and the high concentration of organics in the vapor could provide additional fuel for the incinerator

EXHIBIT 8-5(7)
U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE METAL FURNITURE INDUSTRY

Control Options	Affected Facility and Application	Typical Percent Reduction	Comparison of Control Options
Incineration (continued)			Heat recovery system to reduce fuel consumption would be desirable and would make application and flash-off area usage a viable option

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a. The base case against which these percent reductions were calculated is a high organic solvent coating which contains 25 volume percent solids and 75 percent organic solvent. The transfer efficiencies for liquid coatings were assumed to be 80 percent for spray, 90 percent for dip or flow coat, 93 percent for powders and 99 percent for electrodeposition.

b. This percent reduction in VOC emissions is only across the control device and does not take into account the capture efficiency.

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

8.4 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

This section presents the cost for the most likely control systems and associated VOC reduction benefit. First the costs for the two model plants are presented, which are then extrapolated to the statewide industry.

8.4.1 Model Plant Costs and VOC Reduction Benefits

Two model plants, each with different sizes, were selected for the surface coating of metal furniture. They included an electrostatic spraying line with outputs of 3 million square feet and 48 million square feet of surface area coated per year. Assuming a one-color single-coating line, the capital, operation and maintenance costs for the model plant were estimated. The cost of pretreatment facilities, ovens and plant building was excluded from total capital costs. The annualized cost includes coating materials, utilities, operation and maintenance labor,[1] maintenance material[1] and capital charges (depreciation, interest, taxes, insurance and administrative charges).[2] General plant overhead cost was excluded from the annualized cost. The estimated costs for the model base plant and the incremental costs for the most likely control options are presented in Exhibit 8-6.

The assumptions for the cost estimates are discussed in the RACT guidelines document (EPA-450/2-77-032). It should be noted that the incremental costs, or savings, can change significantly if the underlying assumptions are changed. For example, for a facility that uses 35-40 percent solids coating instead of the model plant assumption of 25 percent, less savings for conversion to higher solids (70 percent) would result. The savings of $6,000 in direct operating costs for converting from 25 percent to 70 percent solids for Model Plant A-1 becomes a $2,000 savings when converting from 38 percent to 70

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[1] Maintenance material and labor charges were assumed to be aproximately equal to 4 percent of the capital cost.

[2] The capital charges were assumed to be 20.3 percent, which includes 10 percent interest and a 10-year loan life and 4 percent taxes and insurance.

EXHIBIT 8-6
U.S. Environmental Protection Agency
ESTIMATED COST OF CONTROL FOR MODEL EXISTING ELECTROSTATIC SPRAY COATING LINES

	Model Plant A-1 (3 Million Square Feet/Yr)				Model Plant A-2 (48 Million Square Feet/Yr)			
	Base Plant Cost	Incremental Costs for Conversion			Base Plant Cost	Incremental Costs for Conversion		
	25% Solids	Higher Solids	Waterborne	Powder	25% Solids	Higher Solids	Waterborne	Powder
Installed capital cost ($000)	255	15	15	60	1,200	62	62	317
Direct operating costs (savings) ($000)	175	(6)	5	17	1,113	(81)	50	343
Capital charges[a] ($000/yr)	53	3	3	12	248	13	13	65
Net annualized cost (credit) ($000/yr)	228	(3)	8	29	1,361	(68)	63	408
Solvent emissions controlled (tons/yr)	N/A	21	20	24	N/A	336	314	380
Percent emissions reduction	N/A	86	80	97	N/A	86	80	97
Annualized cost (credit) per ton of VOC controlled ($/ton)	N/A	(143)	400	1,208	N/A	(202)	201	1,074

Note: 1977 dollars and short tons

a. The capital charges were assumed to be 20.3 percent, which includes 10 percent interest and a 10-year loan life and 4 percent taxes and insurance. This differs from the RACT guideline assumption of 18.6 percent based on a 12-year life.

Source: Booz, Allen & Hamilton Inc., based on Control of Volatile Organic Emissions from Stationary Sources, Volume III: Surface Coating of Metal Furniture, EPA-450/2-77-032, December 1977.

percent solids. Similarly, capital costs for conversion to waterborne coating would increase dramatically if significant changes to the facility were needed, compared to the assumption of cleaning and corrosion protection only.

8.4.2 Extrapolation of Control Costs to the Statewide Industry

Exhibit 8-7, on the following page, presents the extrapolated costs for meeting RACT guidelines for VOC emission control for surface coating of metal furniture to the statewide industry in Tennessee. The estimates are based on the following assumptions and methods:

- Based on emissions estimates presented in Exhibit 8-3, seven plants were assumed to require controls to comply with the RACT guidelines.

- The distribution of control options was based on industry interviews, as well as Booz, Allen estimates. Where information from the industry was not available, existing spray coating lines were assumed to convert to high solids or waterborne coatings depending upon the quality of finish required on the finished product.

- The capital cost of control for high solids and waterborne spray was estimated by scaling up the model plant A-1 costs by a capacity factor calculated as follows. The capacity factor was assumed to be one for the coating lines with emissions per line equal to or less than those of the model plant. For the coating lines with greater emissions per line than those of the model plant, the capacity factor per line was determined to be equal to:

  $(\text{actual emissions/model plant emissions})^{0.6}$

- The annual operating cost for high solids and waterborne spray coating was assumed to be proportional to the amount of emissions reduction and was scaled up from the model plant costs.

EXHIBIT 8-7

U.S. Environmental Protection Agency

STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF EXISTING METAL FURNITURE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL IN TENNESSEE

	Projected Control Option		
Characteristic	High Solids Spray	Waterborne Spray	Total
Number of plants	4	3	7
Number of process lines	5	4	9
Uncontrolled emissions (ton/yr)	685	268	953
Potential emission reduction (ton/yr)[a]	588	214	802
Installed capital cost ($000)[b]	197	108	305
Direct annual operating cost (credit) ($000) (1-3 shifts/day)[c]	(168)	55	(113)
Annualized capital charges (credit) ($000)[c]	40	22	62
Net annualized cost (credit) ($000)	(128)	77	(51)
Annualized cost (credit) per ton of emissions reduced ($)	(217)	360	(64)

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[a] Based on control efficiency of 86 percent for high solids, and 80 percent for waterborne coating.
[b] Based on cost for model plant A-1 from Exhibit 8-6.
[c] 20.3 percent of capital cost.

Source: Booz, Allen & Hamilton Inc.

The data in Exhibit 8-7 show that the control of VOC emissions for surface coating of metal furniture to meet the RACT guidelines in Tennessee would require a statewide capital investment of about $305,000 and result in a statewide net annualized savings of approximately $51,000.

Based on data obtained from U.S. EPA (backup data for RACT guidelines), the conversion to high solids or waterborne coatings could result in an energy savings due to reduced heat requirements. For model plant A-1, for high solids conversion the estimated savings is 129 equivalent barrels of oil per year, and for waterborne spray conversion it is estimated at 171 equivalent barrels per year. Assuming that energy saving is proportional to emissions reduction, the savings for the state would be equivalent to approximately 5,400 barrels of oil annually.

8.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines for surface coating of metal furniture, on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

8.5.1 RACT Timing

RACT must be implemented statewide by September 1, 1981 for low solvent coatings and by November 1, 1981 for equipment modifications. This implies that surface coaters of metal furniture must have made their process modifications and be operating within less than three years. The timing requirements of RACT impose several requirements on metal furniture coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase new equipment or modify existing facilities.
- Acquire the necessary equipment or coating material for emission control.
- Install new equipment or modify existing facilities and test equipment and/or new materials to ensure that the system complies with RACT and provides acceptable coating quality.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

8.5.2. Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

Some metal furniture manufacturers have experimented with waterborne spray coatings, but have not succeeded in obtaining the desired quality finish. None of the metal furniture manufacturers potentially affected by RACT has implemented high solids coatings to date. However, based on interviews with industry representatives, it is predicted that several manufacturers will convert to high solids spray coatings in order to comply with RACT guidelines. These coating materials may not be available in the desired quality and the variety of colors required by the manufacturers. The development of suitable coating materials in a variety of colors is the key to successful implementation of RACT in the required time.

Another problem likely to be encountered by the metal furniture manufacturers is that of excessive use of the high solids coatings. Experiments by one manufacturer in another state indicate that personnel accustomed to high solvent coatings are likely to apply more than the desired thickness of coating, thus using more paint. This problem could be alleviated through training of personnel. It is also possible that the increased demand for high solids coatings may raise the price of these coating materials.

Unless major modifications to equipment are required, for example, automated coating lines or complete isolation of large facilities to convert to electrostatically sprayed waterborne coating, the cost of conversion to high solids or waterborne coatings is not likely to have a significant effect on the implementation of the RACT guidelines for surface coating of metal furniture.

8.5.3 Comparison of Direct Cost With Selected Direct Economic Indicators

The net increase in the annualized cost to the coaters of metal furniture represents approximately 0.05 percent of the industry's 1977 value of shipments manufactured in the state, and 0.09 percent of the value of shipments for the seven affected facilities. This increase may translate to a few cents per unit of furniture manufactured to more than $1 per unit manufactured, depending on the furniture surface area coated.

The major economic impact in terms of cost to most individual companies will be capital related rather than from increased annual operating costs. The capital required for RACT compliance may present a significant capital appropriation problem for the smaller companies, the severity of which will depend upon the ability of these companies to pass on these costs through higher prices. The capital drain could also be reflected in any opportunities lost because of capital usage for RACT compliance.

8.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impacts of implementing RACT on employment, market structure, productivity, and energy consumption.

Employment and market structure in the metal furniture industry are not expected to be significantly affected by the RACT guidelines.

By converting to high solids coatings, productivity could be increased because manufacturers will be able to get more paint on per unit volume basis and reduce paint application time. However, the necessity of converting to airless guns, with slower application of coatings, could reduce coating line speed and thereby reduce productivity for some manufacturers. Line speed is also reduced with the use of waterborne coatings due to increased drying time.

The conversion to high solids or waterborne coatings by the affected manufacturers could result in a net savings of energy equivalent to approximately 5,400 barrels of oil annually.

* * * * *

Exhibit 8-8, on the following page, presents a summary of the current economic implications of implementing the RACT guidelines for surface coating of metal furniture in the State of Tennessee.

EXHIBIT 8-8(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURACE COATING OF METAL FURNITURE IN TENNESSEE

Current Situtation	Discussion
Number of potentially affected facilities	There are seven metal furniture manufacturing facilities
Indication of relative importance of industrial section to state economy	1977 value of shipments was approximately $109 million industry-wide and approximately $58 million for seven affected facilities
1977 VOC emissions (actual)	953 tons per year
Industry preferred method of VOC control	Low solvent coatings
Assumed method of control to meet RACT guidelines	Low solvent coatings
Affected Areas in Meeting RACT	**Discussion**
Capital investment (statewide)	$305,000
Annualized savings (statewide)	$51,000 which represents 0.05 percent of the industry's 1977 value of shipments
Price	Increase from a few cents to over $1/unit depending on the surface area coated
Energy savings	5,400 equivalent barrels of oil per yr.
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements (1982)	Companies using a variety of colors may face a problem finding suitable low solvent coatings

EXHIBIT 8-8(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Problem area	Low solvent coating in a variety of colors providing acceptable quality needs to be developed
VOC emissions after RACT	151 tons per year (approximately 16 percent of current emissions level)
Cost effectiveness of RACT	$64 annualized savings per annual ton of VOC emissions reduction

Source: Booz, Allen & Hamilton Inc.

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Massey Seating, Nashville, Tennessee
G.F. Business Furniture Gallation, Tennessee
Tennesco Dickson, Tennessee
Delwood Furniture Sparta, Tennessee

10.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT GUIDELINES FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT for surface coating of large appliances in the State of Tennessee.[1] The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Emissions and current controls
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of the application of surface coatings on large appliances, interviews and analysis.

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[1] The three urban nonattainment counties are: Davidson, Hamilton and Shelby. In these counties all sources with potential emissions of 25 tons or more per year are regulated. For the rest of the state, all sources with potential emissions of 100 tons or more per year are regulated.

10.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impacts

for the surface coating of large appliances in Tennessee.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

10.1.1 Industry Statistics

The major appliance industry contains six major industrial areas as defined by the Standard Industrial Code (SIC).

SIC Code	Description
3582	Commercial laundry
3585	Commercial refrigeration and air conditioning
3589	Commercial cooking and dishwashing
3631	Household cooking
3632	Household refrigerator and freezer
3633	Household laundry
3639	Household appliances, N.E.C. (includes water heaters, dishwashers, trash compactors)

Current Industrial Reports provides detailed industry statistical data for the major appliance industry on a national basis. However, because of confidentiality and disclosure problems, there is no individual data source which provides a comprehensive analysis of the statistical data for each individual state. Therefore, our methodology to provide statewide major appliance statistical data was as follows:

- A list of potentially affected facilities was compiled from the state emission inventory, associations and trade journals.

- Interviews were performed with some of the manufacturers to validate the list of potentially affected facilities. Most of the firms potentially affected were contacted by the Tennessee Department of Public Health.

- Secondary source data were collected for each of the industry categories from sources such as:

  - Sales and Marketing Management (April 25, 1978)
  - 1972 Census of Manufactures
  - Tennessee Directory of Manufacturers, 1978

- The Booz, Allen study team, utilizing all available inputs, determined an estimated percent of the total U.S. value of shipments applicable to the state in each SIC category.

For those categories which included products not included in this study, the value of shipments of these items were factored out of the totals.

Data on number of units shipped were not available for commercial appliances, so economic impact based on unit costs for the total large appliance industry could not be calculated.

10.1.2 VOC Emissions

The Tennessee EPA provided a list of facilities potentially affected by the implementation of the RACT guidelines. Emissions were listed for 20 companies identified as major emitters in this category. Of the 20 companies identified six are located in the urban nonattainment counties. The emission data provided by the Tennessee EPA survey are used as the basis for current VOC emissions in this report.

Tennessee EPA has neither completed the compilation of emissions data nor completed verifying the list of potentially affected facilities in this RACT category.

10.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for the surface coating of large appliances are described in Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coating of Large Appliances (EPA-450/2-77-034, December 1977).

All manufacturers interviewed for economic impact studies in Region V and in Region IV agreed that, currently, consideration was being given to meeting the present RACT deadlines through modification to the existing topcoating equipment (i.e., high solids) and through possible alternatives to primecoating operations (i.e., waterborne dip or flow coat or high solids), depending on the type of existing equipment. Therefore, the analysis for this report was based on these alternatives. The methodology for the cost analysis is described in the following paragraphs.

10.1.4 Cost of Control of VOC Emissions for Surface Coating of Large Appliances

The costs of control of volatile organic emissions for surface coating of large appliances were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining system components
- Developing installed capital costs for modifications of existing systems
- Aggregating installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of a control system for the model plant:
    - Installed capital cost
    - Direct operating cost
    - Annual capital charges
    - Energy requirements
- Extrapolating model costs to individual industry sectors
- Aggregating costs to the total industry for the state.

The model plant that was used as a basis for establishing the cost of process modification to meet RACT was a solvent-based dip (or flow coat) primecoat and a solvent-based electrostatic bell or disc topcoat. The cost of modification to waterborne dip or flow coat primecoat and to high solids electrostatic disc or bell topcoat was not considered to be a function of the type of major appliance to be coated, since no modifications to the production lines are necessary. Modifications are required only to the coatings handling and pumping and spraying equipment, and these would be approximately the same whether washers, dryers or refrigerators were being coated.

This study will cover exceptions to the model plant used in the economic analysis and requiring major reconstruction and/or modification of existing lines to meet RACT. These exceptions include major alterations to spray booth configurations or installation of electrodeposition for prime coating operations or both. These exceptions will be applied only when specific information has been made available from large appliance coaters as to their applicability.

10.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements to implement RACT, assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability, comparing the direct costs of RACT control to various state economic indicators and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Tennessee.

10.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on the surface coating of large appliances in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (data that are published for the base year), "B" indicates data that were extrapolated from hard data and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analysis of previous studies and best engineering judgment. Exhibit 10-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 10-1
U.S. Environmental Protection Agency
SURFACE COATING OF LARGE APPLIANCES
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		X	
Emissions	X		
Cost of emissions control			X
Economic impact			X
Overall quality of data			X

Source: Booz, Allen & Hamilton Inc.

10.2 INDUSTRY STATISTICS

Industry statistics and business trends for the manufacture and surface coating of large appliances in Tennessee are presented in this section. The discussion includes a description of the number of facilities, a comparison of the size of the major appliance industry to the state economic indicators, a historical characterization of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions in Tennessee.

10.2.1 Size of the Industry

The Tennessee EPA reports and Booz, Allen has identified 20 companies participating in the manufacture and coating of large appliances, six of which are in urban nonattainment counties, as shown in Exhibit 10-2, on the following page. These companies accounted for between $0.9 billion and $1.2 billion in shipments. The estimated number of employees in 1977 was between 12,000 and 13,000. The data and the sources of information are summarized in Exhibit 10-3, following Exhibit 10-2, and indicate that Tennessee shipped an estimated 6 percent to 8 percent of the U.S. value of shipments in the large appliance industry.

10.2.2 Comparison of the Industry to the State Economy

A comparison of the value of shipments of large appliances (in the SIC categories stated previously) with the state economy indicates that the large appliance industry represents 3.0 percent to 4.5 percent of the total Tennessee value of shipments of all manufactured goods. The industry employs between 2.5 percent and 3.0 percent of all people employed in manufacturing in Tennessee. These figures are shown in Exhibit 10-4, following Exhibit 10-3, along with the sources of the data.

10.2.3 Historical and Future Patterns of the Industry

The shipments of major appliances have generally followed the economic condition of the country. In the last ten years, sales have generally increased annually, except during the recession in 1974 and 1975. Shipments peaked in 1973 for all major appliances.

Shipments picked up in 1976 and continued to grow in 1977. The outlook through 1982 is a continued annual growth of about 3 percent to 5 percent.

EXHIBIT 10-2

U.S. Environmental Protection Agency
LIST OF MANUFACTURERS, POTENTIALLY AFFECTED BY RACT GUIDELINES, WHO SURFACE COAT LARGE APPLIANCES IN TENNESSEE

Facility Name	Location
Amana Refrigeration	Fayetteville
Athens Stove Works	Athens
Brown Stove Works	Cleveland
Carrier[a]	Collierville
Carrier	McMinnville
Duo-Therm	Alamo
General Electric	Columbia
Gray & Dudley Company[a]	Nashville
Hardwick Stove	Cleveland
Heil Quaker[a]	Nashville
ITT Nesbitt	Jackson
Magic Chef	Cleveland
Modern Maid[a]	Chattanooga
Mor-Flo Indus	Johnson City
State Industr	Ashland City
Suburban Manufacturing	Dayton
Tappan Company	Springfield
Trane Company	Clarksville
U.S. Stove Company[a]	South Pittsburg
W. L. Jackson[a]	Chattanooga

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[a] Located in urban nonattainment counties.

Source: Tennessee EPA and *Tennessee Directory of Manufacturers*, 1978

EXHIBIT 10-3

U.S. Environmental Protection Agency

INDUSTRY STATISTICS--SURFACE COATING OF LARGE APPLIANCES TENNESSEE

SIC Code	RACT Category	U.S. Totals[a] 1977: Estimated No. of Units Shipped (thousand)	U.S. Totals[a] 1977: Estimated Value of Shipments ($ million)	Tennessee Totals[a]: Estimated Percent of U.S. Shipments	Tennessee Totals[a]: Estimated Value of Shipments ($ million)	Tennessee Totals[a]: Estimated No. of Units Shipped (thousand)
3582	Commercial laundry	b	200	-	-	-
3585	Commercial refrigeration and air conditioning	b	9,500	4-6	400-500	b
3589	Commercial cooking and dishwashing	b	150	-	-	-
3631	Household cooking	5,000	1,500	25-35	400-500	1,300-1,700
3632	Household refrigerator and freezer	7,300	2,000	-	-	-
3633	Household laundry	8,500	1,500	-	-	-
3639	Household appliances: Water heaters Dishwashers Trash compactors	9,300	800	17-20	140-160	1,600-1,900
	TOTAL		15,650	6-8	940-1,160	2,900-3,600

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a. Current Industrial Reports, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639. 1972 Census of Manufactures Service Industry Machine Shops (issued March 1975 and updated to 1977) for categorie 3582, 3585 and 3589. Sales and Marketing Management (April 25, 1977) for categories 3631, 3632, 3633 and 3585.

b. Not available

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 10-4

U.S. Environmental Protection Agency

COMPARISON OF LARGE APPLIANCE STATISTICS WITH STATE OF TENNESSEE ECONOMIC DATA

	Estimated Tennessee Economic Indicators	Estimated Percent of Tennessee Manufacturing Economy Engaged in Large Appliance Manufacturing
Total 1977 value of shipments of all manufactured goods	$26-32 billion	3.0 to 4.5
Number of employees in manufacturing	476,000	2.5 to 3.0

Source: Current Industrial Reports, Major Household Appliances, 1977 (issued June 1978) for categories 3631, 3632, 3633 and 3639; 1972 Census of Manufactures Industry Machines and Machine Shops (issued March 1975 and updated to 1977) for categories 3582, 3585 and 3589; Sales and Marketing Management (April 25, 1977) for categories 3631, 3632, 3633 and 3585; Sales and Marketing Management, April 24, 1978; Annual Survey of Manufactures, Statistics for States Standard Metropolitan Statistical Areas, Large Industrial Counties and Selected Cities, 1976, Tennessee Directory of Manufacturers, 1978; Booz, Allen & Hamilton Inc.

The growth of the major appliance market will be reflected in the growth of the housing industry and the socio-economic effects of the trends toward smaller families, single-person households, higher energy costs and the like.

Historical and future growth patterns are shown in Exhibits 10-5 and 10-6, on the following pages.

EXHIBIT 10-5
U.S. Environmental Protection Agency
HISTORICAL U.S. SALES FIGURES--SELECTED MAJOR HOUSEHOLD APPLIANCES FOR 1968-1977

	Appliance Sales (Millions Of Units)									
Appliance	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Washer	2.9	4.4	4.1	4.6	5.1	5.5	4.9	4.2	4.5	4.9
Dryer	2.9	3.0	2.9	3.3	3.9	4.3	3.6	2.9	3.1	3.6
Range	4.4	4.5	4.5	4.3	4.8	5.0	4.1	3.6	4.2	4.7
Dishwasher	1.9	2.1	2.1	2.5	3.2	3.7	3.3	2.7	3.1	3.4
Refrigerator	5.2	5.3	5.3	5.7	6.3	6.8	5.9	4.6	4.8	5.7

10-7-a

Source: *Appliance*, April 1978, pp. 37-40.

EXHIBIT 10-6

U.S. Environmental Protection Agency
FIVE-YEAR U.S. SALES FORECAST FOR SELECTED MAJOR HOUSEHOLD APPLIANCES
(1978-1982)

Appliance	Appliance Estimates (Millions Of Units)				
	1978	1979	1980	1981	1982
Washer	5.4	5.6	5.7	5.8	5.8
Dryer	4.0	4.2	4.4	4.5	4.6
Range	5.2	5.4	5.6	5.7	5.8
Dishwasher	3.7	3.9	4.1	4.4	4.6
Refrigerator	6.0	6.2	6.4	6.5	6.6

Source: *Appliance*, January 1978, pp. 54-55.

10-7-b

10.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents the process description for the preparation, application and curing of surface coatings for large appliances, estimated VOC emissions from facilities coating large appliances in Tennessee and the extent of current control in use.

10.3.1 Large Appliance Process Description

A large appliance plant typically manufactures one or two types of appliances and contains only one or two lines. The lines may range from 1,200 to 4,000 meters (3/4 mile to 2-1/2 miles) in length and operate at speeds of 3 to 15 meters (10 to 50 feet) per minute.

Cases, doors, lids, panels and interior parts for large appliances are stamped from sheet metal and hung on overhead conveyors. The parts are transported to the cleaning and pretreatment sections which are typically located on the ground floor of the plant.

Exhibit 10-7 and Exhibit 10-8, on the following pages, describe and illustrate the pretreatment, coating and curing processes for a typical large appliance facility.

EXHIBIT 10-7
U.S. Environmental Protection Agency
PRESENT MANUFACTURING TECHNOLOGY DESCRIPTION

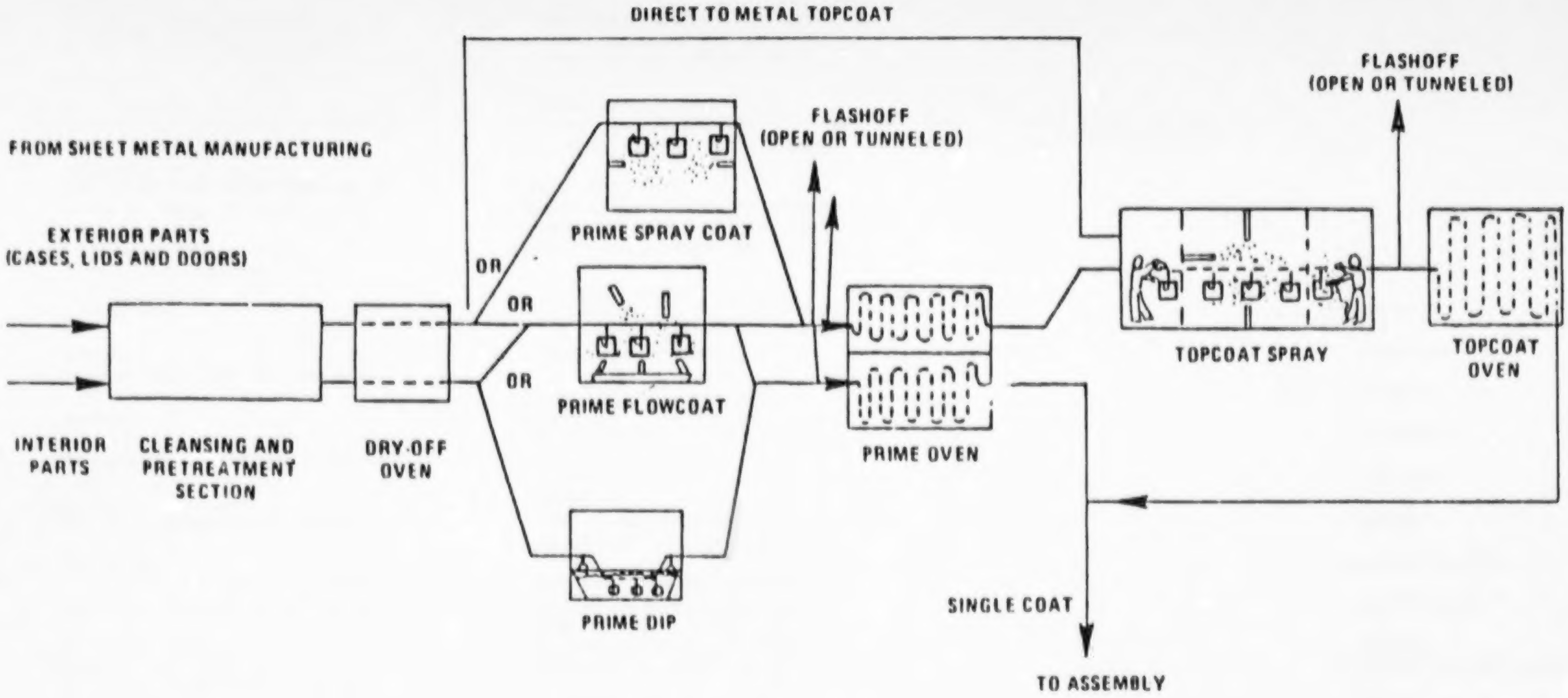
MANUFACTURING AND PRETREATMENT PROCESS DESCRIPTION	COATING PROCESS DESCRIPTION	CURING PROCESS DESCRIPTION	TYPICAL COATINGS AND SOLVENTS
Large appliance plant typically manufactures one or two different types of appliances and contains only one or two lines . Lines may range from 1,200 to 4,000 meters (3/4 to 2-1/2 miles) in length . Lines may operate at speeds of 3 to 15 meters (10 to 50 feet) per minute Parts are transported on overhead conveyors . Cleaned in an alkaline solution . Rinsed . Treated with zinc or iron phosphate . Rinsed again . Treated with chromate (if iron phosphate is used) . Dried at 300°F to 400°F in a gas fired oven and cooled before coating	Primecoat or interior single coat (0.5 to 1.0 mils) is applied . Dip coating occurs in a continuously agitated tank . Flow coating occurs in an enclosed booth as the parts move through on a conveyor and are sprayed by stationary or oscillating nozzles - Parts may enter a flash-off tunnel to allow coating to flow out properly . Spray coating occurs in booths either by automatic electrostatic spraying or manually - Flashoff of 7 minutes to allow solvents to rise slowly in the film to avoid popping in the oven Prior to topcoating, the parts are checked for smoothness and manually sanded, "tack-ragged" or retouched with a spray gun	Coated parts are baked for about 20 minutes at 180°C to 230°C (350°F to 450°F) in a multipass oven	Coatings include: . Epoxy . Epoxy-acrylic . Acrylic or polyester enamels . Alkyd resins Solvents include: . Esters . Keytones . Aliphatics . Alcohols . Aromatics . Ethers . Terpenes
Exterior parts may enter a prime preparation booth to check the pretreatment . Parts can be sanded and tack-ragged (wiped) to provide an even finish	Topcoat or exterior single coat (direct-to-metal topcoat (1.0 to 1.5 mils) is applied . Usually applied by automated electrostatic discs, bell or other type of spray equipment . Usually applied in many colors . Applied in side-draft or down-draft spray booths equipped with water wash and undergoes a 10-minute flashoff period Inside of many exterior large appliance parts are sprayed with gelsonite for additional moisture resistance and for sound deadening	Baked for 20 to 30 minutes at 140°C to 180°C (270°F to 350°F) in a multipass oven	

10-8-a

Reproduced from best available copy.

Source: Control of Volatile Organic Emissions From Existing Stationary Sources -- Volume V: Surface Coatings Of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-8
U.S. Environmental Protection Agency
DIAGRAM OF A LARGE APPLIANCE COATING LINE


DIRECT TO METAL TOPCOAT
FROM SHEET METAL MANUFACTURING
EXTERIOR PARTS (CASES, LIDS AND DOORS)
INTERIOR PARTS
CLEANSING AND PRETREATMENT SECTION
DRY-OFF OVEN
OR
OR
OR
PRIME SPRAY COAT
PRIME FLOWCOAT
PRIME DIP
FLASHOFF (OPEN OR TUNNELED)
PRIME OVEN
TOPCOAT SPRAY
FLASHOFF (OPEN OR TUNNELED)
TOPCOAT OVEN
SINGLE COAT
TO ASSEMBLY

Source: Control Of Volatile Organic Emissions From Existing Stationary Sources--Volume V: Surface Coating Of Large Appliances, EPA-450/2-77-034, December 1977.

10.4 EMISSIONS AND CURRENT CONTROLS

This section presents information on the distribution of VOC emissions during the coating operation, the estimated VOC emissions in Tennessee in 1977 and the current level of emission control implemented in the state.

VOC emissions occur in three areas during the process of coating large appliances. They are the application, flashoff and oven areas. The percent distribution of VOC emissions by area is as follows:

	Percent of VOC Emission	
Application Method	Application and Flashoff	Oven
Dip	50	50
Flow coat	60	40
Spray	80	20

Applicability of RACT to meet the 2.8 pounds of solvent per gallon of coating (minus water) for current operations would provide emission reduction of 80 percent for primecoating and 60 percent for topcoating. Assuming equal emissions for both coating operations, this leads to an average emissions control efficiency with RACT of 70 percent.

Exhibit 10-9, on the following page, shows the total estimated emissions in tons per year from coaters of major appliances in Tennessee. The Tennessee EPA and Booz, Allen study team estimated emissions in Tennessee from 20 appliance coating facilities are 3,323 tons per year.

10.4.1 RACT Guidelines

The RACT guidelines for control of VOC emissions from the surface coating of major appliances require the following:

- Use of waterborne, high solids (at least 62 percent by volume) or powder coating to reduce VOC emissions, or
- Use of add-on control devices, such as incinerators or carbon adsorbers.

Exhibits 10-10, 10-11 and 10-12, following Exhibit 10-9, summarize the RACT emission limitations and control options for VOC emissions control for surface coating of large appliances.

EXHIBIT 10-9

U.S. Environmental Protection Agency

RACT DATA SUMMARY FOR ESTIMATED VOC EMISSIONS FOR SURFACE COATING OF LARGE APPLIANCES IN STATE OF TENNESSEE

Facility Name	1977 Average Hydrocarbon Emissions (Ton/Year)	Average Control Efficiency with RACT (Percent)	Potential Emission Reduction with RACT (Ton/Year)
Amana Refrigeration	116	70	81
Athens Stove Works	78	70	55
Brown Stove Works[b]	119	70	83
Carrier[a]	102	70	71
Carrier	307	70	215
Duo-therm	63	70	44
General Electric	109	70	76
Gray & Dudley Co.[ab]	87	70	61
Hardwick Stove	86	70	60
Heil Quaker[a]	260	70	182
ITT Nesbitt	113	70	79
Magic Chef	278	70	195
Modern Maid[a]	306	70	214
Mor-Flo Industries	228	70	160
State Industries	545	70	382
Suburban Manufacturing	104	70	73
Tappan Company	46	70	32
Trane Company	183	70	128
	58	70	41
U.S. Stove Company[a]	122	70	85
W. L. Jackson[a]	13		9
Total	3,323		2,326
Total	3,323		2,326

10-9-a

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a. Facilities located in urban nonattainment counties

b. Emissions estimated by Booz, Allen based on number of employees

Source: Tennessee EPA; Tennessee Directory of Manufacturers, 1978, Booz, Allen & Hamilton Inc.

EXHIBIT 10-10

U.S. Environmental Protection Agency EMISSION LIMITATIONS FOR RACT IN THE SURFACE COATING OF LARGE APPLIANCES

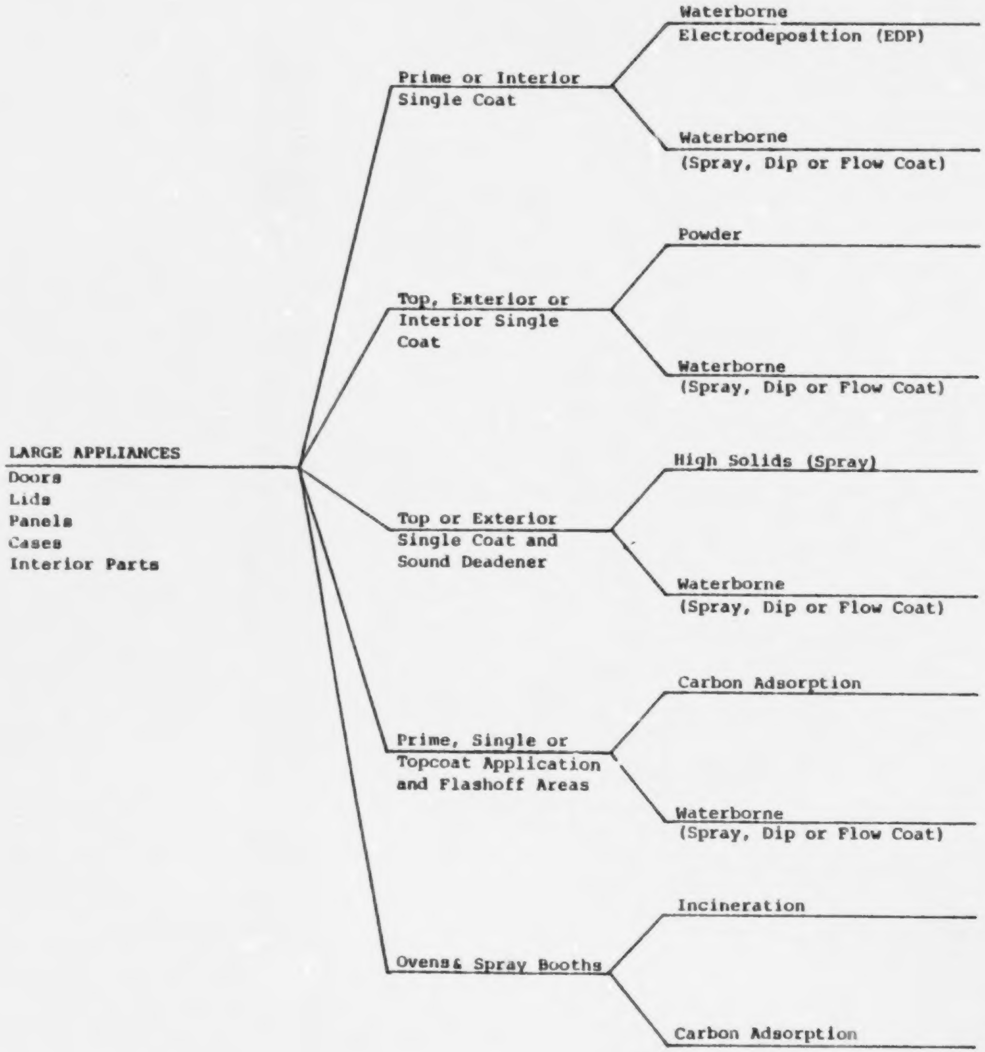
Affected Facility	Recommended Limitations For Low Solvent Coatings: kg solvent per liter of coating (minus water)	Recommended Limitations For Low Solvent Coatings: lbs. solvent per gallon of coating (minus water)
Prime, single or topcoat application area, flash-off area and oven	0.34	2.8

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-11

U.S. Environmental Protection Agency

SUMMARY OF APPLICABLE CONTROL TECHNOLOGY FOR COATING OF LARGE APPLIANCE DOORS, LIDS, PANELS, CASES AND INTERIOR PARTS


LARGE APPLIANCES
Doors
Lids
Panels
Cases
Interior Parts
Prime or Interior Single Coat
Waterborne Electrodeposition (EDP)
Waterborne (Spray, Dip or Flow Coat)
Top, Exterior or Interior Single Coat
Powder
Waterborne (Spray, Dip or Flow Coat)
Top or Exterior Single Coat and Sound Deadener
High Solids (Spray)
Waterborne (Spray, Dip or Flow Coat)
Prime, Single or Topcoat Application and Flashoff Areas
Carbon Adsorption
Waterborne (Spray, Dip or Flow Coat)
Ovens& Spray Booths
Incineration
Carbon Adsorption

Source: Control of Volatile Organic Emissions from Existing Stationary Sources--Volume V: Surface Coating of Large Appliances, EPA-450/2-77-034, December 1977.

EXHIBIT 10-12(1)

U.S. Environmental Protection Agency
RACT CONTROL OPTIONS FOR THE LARGE APPLIANCE INDUSTRY

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Prime or interior single coat	Waterborne (electrodeposition, EDP)	90-95[a]	Provides excellent coverage corrosion protection and detergent resistance Fire hazards and potential toxicity are reduced Dry off oven may be omitted after cleansing if an iron-phosphate pretreatment is used Lower energy consumption via lower ventilation requirements Good quality control due to fully automated process may be offset by increased electrical requirements for the coating, refrigeration and circulation systems if EDP replaces waterborne flow or dip coating operations This would not be true if EDP replaces a spraying operation EDP can be expensive on small-scale production lines
All applications	Waterborne (spray dip or flow coat)	70-90[a]	This will likely be the first option considered because of the possibility that these coatings can be applied essentially with existing equipment Requires a longer flash-off area than organic solvent-borne coatings Curing waterborne coatings may allow a decrease in oven temperature and some reduction in airflow but limited reduction if high humidity conditions occur

EXHIBIT 10-12(2)
U.S. Environmental Protection Agency

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
			Spraying electrostatically requires electrical isolation of the entire system. Large lines may be difficult to convert because coating storage areas may be hundreds or thousands of feet away from the application area
			Dip or flow coating application requires closer monitoring due to their sensitive chemistry
			Weather conditions affect the application, so both flash-off time, temperature, air circulation and humidity must be frequently monitored
			Changes in the number of nozzles may be required
			Sludge handling may be more difficult
Top, exterior or interior single coat	Powder	95-99[a]	No solid or liquid wastes to dispose of
			Powder may reduce energy requirements in a spray booth and the ovens because less air is required than for solvent-borne coatings and flash-off tunnel is eliminated
			Powder can be reclaimed resulting in up to 98% coating efficiency
			All equipment (spray booths, associated equipment and often ovens) used for liquid systems must be replaced
			Powder films cannot be applied in thicknesses in less than 2 mils and have appearance limitations
			Powder coatings may be subject to explosions
			Excessive downtime (half-hour) is required during color changes. If powders are not reclaimed in their respective colors, coating usage efficiency drops to 50% to 60%

10-9-e

EXHIBIT 10-12(3)
U.S. Environmental Protection Agency

Affected Facility and Application	Control Options	Typical Percent Reduction	Comparison of Control Options
Top or exterior single coat and sound deadener	High solids (spray)	60-80[a]	May be applied with existing equipment Reduces energy consumption because it requires less airflow in the spray booth, oven and flash-off tunnel Potential health hazard associated with isocyanates used in some high-solid two-component systems
Prime, single of top coat application and flash-off and spray booths	Carbon adsorption	90[b]	Although it is technically feasible, no larger appliance facilities are known to use carbon adsorption Additional energy requirements is a possible disadvantage Additional filtration and scrubbing of emissions from spray booths may be required There is little possibility of reusing recovered solvents because of the variety of solvent mixtures Many facilities may require dual-bed units which will require valuable plant space Particulate and condensible matter from volatilization and/or degradation of resin occuring in baking ovens with high temperature could coat a carbon bed
Ovens	Incineration	90[b]	These are less costly and more efficient than carbon adsorbers for the baking ovens because the oven exhaust temperatures are too high for adsorption and the high concentration of organics in the vapor could provide additional fuel for the incinerator Heat recovery system to reduce fuel consumption would be desirable and would make application and flash-off area usage a viable option

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a. The base case against which these percent reductions were calculated is a high organic solvent coating which contains 25 volume percent solids and 75 percent organic solvent. The transfer efficiencies for liquid coatings were calculated to be 80 percent, for powders about 93 percent and for electrodeposition about 99 percent.

b. This percent reduction in VOC emissions is only across the control device and does not take into account the capture efficiency.

Source: Control of Volatile Organic Emissions from Stationary Sources--Volume V: Surface Coatings of Large Appliances EPA-450/2-77-034, December 1977.

10-9-F

10.4.2 Selection of the Most Likely RACT Alternatives

The choice of application of control alternatives, for the reduction of hydrocarbon emissions in existing facilities for the surface coating of large appliances, requires a line-by-line evaluation. A number of factors must be considered, based on the individual characteristics of the coating line to be controlled. The degree of economic dislocation is a function of these factors.

The first factor to be considered is whether the existing equipment can be used by the substitution of a coating material which will meet the RACT guideline. This alternative would require the least capital expenditure and minimize production downtime.

If the existing equipment has to be modified, replaced or added to, factors to consider are the kinds of changes that have to be made, the capital costs, the change in operating costs, the length of time needed to make the changes, the effect on the production rate, the operational problems that will have to be handled and the effect on the quality of the product.

Interviews with industry representatives from economic impact studies completed in Region V and in Region IV indicate an unanimous opinion in the area of choosing the alternative(s) for VOC emission control in coating large appliances. The industry intends to use their existing topcoat application equipment and modify it to handle high solids. Those companies that use a primecoat will convert their conventional enamel systems to either waterborne dip or flow coat or high solids discs, bells or spray guns. The alternatives are shown in Exhibit 1013, on the following page.

Those unique applications, where conversion from conventional enamel to waterborne coatings requires the implementation of technology alternatives other than the ones stated above (i.e., electrodeposition), will be addressed in this study on an individual basis, as the information is made available from industry interviews.

EXHIBIT 10-13
U.S. Environmental Protection Agency
MOST LIKELY RACT CONTROL ALTERNATIVES FOR SURFACE COATING OF LARGE APPLIANCES IN STATE OF TENNESSEE

Coat	Existing System	Most Likely Alternative Control Techniques
Prime	Dip or flow coating with conventional solvent	Dip or flow coating with waterborne solvent Electrostatic application with discs or bells of high solids coatings . Preheat, paint, or . Use high speed discs or bells Electrodeposition[a]
Top	Electrostatic application with discs, bells or guns of conventional solvents	Electrostatic application with discs, bells or spray nozzles of high solids coating . Preheat paint, or . Use high speed discs or bells

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[a] Only for applications where conversion to waterborne flow coating will not meet the minimum coverage specifications originally provided by conventional enamel flow coating.

Source: Booz, Allen & Hamilton Inc.

10.5 COST AND VOC REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for the VOC emission control systems are presented in this section. The costs for the alternative primecoat and topcoat applications are described individually. The final section presents an extrapolation of typical costs for surface coating of large appliances to the statewide industry.

10.5.1 Costs for Alternative Control Systems

Estimates of capital and annualized costs are presented for controlling solvent emissions from application areas and curing ovens in primecoats and topcoats of large appliances.

The process modifications involve the converting of a solventborne primecoat or topcoat line to a coating system which emits lesser amounts of VOC. The coating lines and the costs for their modification are shown in Exhibit 10-14, on the following page.

If an existing primecoat conventional-solvent-based dip operation is converted to waterborne dip, the capital costs cover the requirements for additional equipment for close humidity and temperature control during flashoffs and for changeover to materials handling system (pumps and piping) that can handle waterborne coatings without corrosion related problems. Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $15,000 and $20,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

For the conversion of primecoat or topcoat solvent-based electrostatic disc bell or nozzle spray to high solids, the cost of such conversion is based on a number of assumptions: that the paint will have to be preheated to reduce the viscosity prior to application, that the existing pumping system will have to be replaced (including the installation of larger capacity/head pumps and large diameter piping) and that high speed (25,000 to 50,000 RPM) turbine or air drive discs or bells or larger diameter nozzles will be required. Also, it is assumed that the type of booth remains unchanged and that the existing painting configuration (including the proper indexing layout) requires no change.

EXHIBIT 10-14
U.S. Environmental Protection Agency·
ESTIMATED COST FOR PROCESS MODIFICATION
OF EXISTING LARGE APPLIANCE COATING LINES
TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL

Existing System	Most Likely Control Alternative	Major Process Modification	Capital Cost
Primecoat			
Conventional solvent-based dip or flow	Waterborne dip of flow coat	Instrumentation for close control of temperature and humidity Total repiping and replacement of pumps	Installed capital $50,000 - $75,000 Annualized cost $15,000 - $20,000
	Electrodeposition	Replace existing system with EDP equipment (including washing; ultrafiltration; deionization)	Installed capital $300,000 - $500,000 Annualized cost $75,000 - $125,000
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Pre-heating system Installation of high disc or bells Replacement of spray nozzles Repiping for larger line sizes and possible coatings pump replacements	Installed capital $50,000 - $75,000 Annualized cost $15,000 - $20,000
		Major revamp of booth line configuration and air handling system in addition to changes stated above	Installed capital $150,000 - $250,000 Annualized cost $37,000 - $63,000
Topcoat			
Conventional solvent-based electrostatic spray, disc or bell	High solids electrostatic	Preheating system Installation of high speed disc or bells Replacement of spray nozzles Repiping for larger line sizes and possible possible coatings pump replacement	Installed capital $50,000 - $75,000 Annualized cost $15,000 - $20,000
		Major revamp of booth configuration and air handling system in addition to changes stated above	Installed capital $750,000 - $250,000 Annualized cost $37,000 - $63,000

Source: Booz, Allen & Hamilton Inc.

Based on these assumptions, the capital installed cost of these modifications is estimated at between $50,000 and $75,000. No additional floor space is required so the capital allocated building costs remain unchanged. The fixed costs associated with the increased capital requirements are estimated at between $15,000 and $20,000. This includes depreciation, interest, taxes, insurance, administration expenses and maintenance materials.

Each paint application conversion to meet RACT has its own unique characteristics. Where such conversions require major changes in booth structure, paint application techniques and air handling system, the costs will be considerably higher than the figures stated above. A first pass estimate at these major changes indicates a capital requirement of $150,000 to $250,000 per booth. The annualized costs would be $37,000 to $63,000.

In special applications areas, such as the primecoating of air conditioner cases, the conversion to waterborne dipcoating will not meet the minimum coverage requirements previously provided by conventional enamel dipcoating. In this case, the conversion to electrodeposition primecoating and high solids topcoating may be necessary both to meet RACT and to provide adequate exposure protection for the product.

The cost of electrodeposition, as developed by Springborn Laboratories (under EPA contract number 68-02-2075), is estimated at $500,000 capital installed. The annualized costs would be approximately $125,000.

The annual operating expenses will not change appreciably because the manpower requirements remain the same for the two systems. There will be a minor savings in the utilities, associated with the oven curing of the high solids coating. This could amount to about $1 per hour of operation time ($2,000 to $6,000 per year per line (equivalent to 700 cubic feet of natural gas/hour/line).

The overall cost of coating materials may increase slightly even though conversion to water-based or high solids coating will eliminate the need for solvent thinning. This overall increase is expected because of the anticipated price increases in the coatings that will be required to meet the RACT guidelines. At this time, definitive numbers in change of paint prices cannot be developed but an overall paint cost increase of between 10 percent and 20 percent may be anticipated.

10.5.2 Extrapolation to the Statewide Industry

Exhibit 10-15, on the following page, extrapolates the costs for meeting RACT guidelines for VOC emission control for surface coating of large appliances to the statewide industry in Tennessee. The estimates are based on the following assumptions:

- All large appliance coaters will implement the control alternatives stated in this report to comply with RACT.
- The distribution of primecoat or topcoat or both as applications, as per industry interview, is: 50 percent of the coaters topcoat only; the other half both primecoat and topcoat the appliances, unless specific information was available for individual facilities.
- 50 percent of the topcoat applications require major modifications to meet RACT.
- For those companies that coat household air conditioners, the number of the processing lines was estimated based on typical emissions from other states studied, and the lines require installation of both electrodeposition primecoat and high solids topcoat application equipment.
- The 20 plants identified by the Tennessee EPA and Booz, Allen represent the majority of all the state industry production of large appliances.
- For the specific alternatives listed in Exhibit 10-14, the cost of process modifications for the prime or top coat operations are the same.

Actual costs to large appliance coaters may vary depending on the type of control alternative, manufacturer's equipment and coating material selected by each manufacturing facility.

Based on the above assumptions, the total capital cost to the industry in Tennessee for process modifications to meet RACT guidelines is estimated at $6.6 million. The annual cost is estimated at $663 to $694 per ton of emission controlled.

EXHIBIT 10-15
U.S. Environmental Protection Agency
STATEWIDE COSTS FOR PROCESS MODIFICATIONS OF EXISTING LARGE APPLIANCE COATING LINES TO MEET RACT GUIDELINES FOR VOC EMISSION CONTROL
TENNESSEE

Characteristic	Flow Or Dip Coat Operations Converting To Waterborne	Flow Or Dip Coat Operations To Electrodeposition	Spray Operations Requiring Average Modifications	Spray Operations Requiring Major Modifications	Total
Number of applications	7	7	11	7	32
Estimated value of shipment ($ billion)	a	a	a	a	0.9-1.2
Uncontrolled emissions (tons/year)	a	a	a	a	4,575
Potential emission reduction (tons/year)	a	a	a	a	3,202
Installed capital cost[b] ($ thousand)	525	3,500	825	1,750	6,600
Direct annual operating cost (credit) ($ thousand) (1-3 shifts per day)	a	a	(22-66)	(14-42)	(36-108)
Annual capital charges ($ thousand)	131	875	206	438	1,650
Net annualized costs[c] ($ thousand)	131	875	140[d]-184[e]	396[d]-424[e]	1,542[d]-1,614[e]
Annual cost per ton of emission reduced ($)	a	a	a	a	663[d]-694[e]

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a. Not available
b. Figures represent the upper limit of the installed capital costs.
c. Net annualized cost is the summation of the direct annual operating cost and the annual capital charges.
d. Represents a three shift per day operation.
e. Represents a one shift per day operation.

Source: Booz, Allen & Hamilton Inc.

10.6 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing the RACT guidelines for surface coating of large appliances on a statewide basis. The analysis includes the availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

10.6.1 RACT Timing

There are three RACT final compliance schedules for Tennessee. They are as follows:

- Low solvent coating implementation by September 1, 1981
- Equipment modification implementation by November 1, 1981
- Add-on control system implementation by November 1, 1981.

The timing requirements of RACT impose several requirements on major appliance coaters:

- Determine the appropriate emission control system.
- Raise or allocate capital to purchase equipment.
- Acquire the necessary equipment for emission control.
- Install and test the emission control equipment to insure that the system complies with RACT.
- Generate sufficient income from current operations to pay the additional annual operating costs incurred with emission control.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

10.6.2 Technical Feasibility Issues

Technical and economic feasibility issues of implementing the RACT guidelines are discussed in this section.

Only one major appliance manufacturer interviewed for economic impact studies for Region V and Region IV has attempted to implement the control alternatives discussed in this report. The company has converted its conventional solvent flow primecoat to water reducible flow coat. Although a longer flash-off period for water reducible coatings is usually required, there was not enough floor space available to add the process line. However, additional heating was added and the flash-off area temperature was elevated to 130°F-180°F. Also, extensive humidity controls had to be added because of the sensitivity of water reducible finish to moisture in the flash-off area.

The facility also has attempted the application of medium solids polyester (55 percent to 60 percent by volume) as a top-coat, using the existing electrostatic discs. There has been no attempt at preheating the paint, and the discs have been run at 2,400 RPM to 3,300 RPM. The unit, as it is presently constituted, will not apply 62 percent volume solids or higher. Preheat and/or higher speed disc modifications will have to be made to handle the more viscous coatings. Under the present operating conditions, the facility is not meeting the RACT guidelines for solvent emission control.

The equipment manufacturers interviewed have indicated that present technology is available to handle and apply high solids (greater than 62 volume percent solids) using electrostatic discs or bells. This requires the use of preheaters and high speed application. In addition, high solids coating material suppliers indicated that sufficient quantities of paint would be available to meet the expected market demand. Application equipment manufacturers have indicated that, even with the projected demand for their equipment, they can maintain a 10-week to 12-week delivery schedule. However, we believe that significant delivery delay may occur if all appliance coaters require delivery of such equipment within the same timeframe.

10.6.3 Comparison of Direct Cost with Selected Direct Economic Indicators

The net increase in the annualized cost to the coaters of large appliances represents approximately 0.15 percent of the industry's 1977 value of shipments manufactured in the state. This increase may translate to an approximate cost increase of $0.40 per unit of household appliance coated; the average cost of a unit is $183.

The major economic impact in terms of cost to individual companies will be capital related rather from increased annualized costs. The capital required for RACT compliance could represent a significant amount of capital appropriations for the companies affected.

Marginally profitable companies may be affected to a greater degree, because of the projected increased capital requirements and inability to pass on these costs through higher prices.

10.6.4 Selected Secondary Economic Impacts

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

Employment is expected to remain unchanged. Employment would be reduced if marginally profitable facilities closed, but the present indication from the industry is that no such closures are anticipated.

It appears that implementation of the RACT guidelines will have no significant impact on the present market structure. The major appliance industry can be characterized as being highly competitive and manufacturers interviewed state that the regulation may present some cost inequities to smaller and/or less profitable production lines, i.e., direct cost increases will probably not be passed along in the marketplace in the form of a price increase and could further deteriorate the profit position of marginally profitable operations.

Productivity for those coaters who are topcoating only with high solids may be increased if they are able to get more paint on per unit volume and reduce paint application time.

* * *

Exhibit 10-16, on the following page, presents a summary of the current economic implications of implementation RACT for surface coating of large appliances in the state of Tennessee.

EXHIBIT 10-16

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SURFACE COATING OF LARGE APPLIANCES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	There are 20 major large appliance manufacturers and coaters
Indication of relative importance of industrial section to state economy	1977 statewide value of shipments is approximately $1.0 billion and represents 7 percent of the estimated $15 billion U.S. value of shipments of the major appliance industry
1977 VOC emissions (actual)	3,323 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat
Assumed method of VOC control to meet RACT guidelines	Waterborne primecoat and high solids topcoat

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$6.6 million
Annualized cost (statewide)	$1.6 million which represents 0.15 percent of the industry's 1977 statewide value of shipments.
Price	Assuming a "direct cost pass-through"--increase of $0.40/unit for household appliances (based on a price of $183 per unit appliance)
Energy	Reduced natural gas requirements in the curing operation (equivalent to 3,430 barrels of oil per year)
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
RACT timing requirements	Possible problems meeting equipment deliveries and installation are anticipated
Problem area	Commercial application of high solids (greater than 62% by volume) has not been proven
VOC emission after RACT control	997 tons/year (30 percent of 1977 emission level)
Cost effectiveness of RACT control	$680 annualized cost/ton VOC reduction

Source: Booz, Allen & Hamilton, Inc.

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Private conversations with:

Association of Home Appliances Manufacturers, Chicago, Illinois
General Electric Corp., Louisville, Kentucky

11.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF TENNESSEE[1]

This chapter summarizes the estimated economic impact of the implementation of reasonably available control technology for volatile organic compound emissions from solvent metal degreasers in Tennessee. Solvent metal degreasing is the process of cleaning the surfaces of articles to remove oil, dirt, grease and other foreign material by immersing the article in a vaporized or liquid organic solvent. The chapter is divided into five sections:

- Specific methodology
- Industry statistics
- Estimated costs of RACT implementation
- Direct economic impacts
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analysis of the RACT guidelines; previous studies of metal degreasing; interviews with degreaser users, equipment and material suppliers; and a review of pertinent published literature.

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[1] The proposed state regulations to control VOC emissions from solvent metal cleaning apply to those facilities with potential emissions over 25 tons per year in three urban counties (Davidson, Hamiltion, and Shelby) and over 100 tons per year in the rural counties in the state.

11.1 SPECIFIC METHODOLOGY

11.1.1 Background

Solvent metal cleaning describes those processes using nonaqueous solvents to clean and remove soils from metal surfaces. These solvents, which are principally derived from petroleum, include petroleum distillates, chlorinated hydrocarbons, ketones and alcohols. Organic solvents, such as these, can be used alone or in blends to remove water-insoluble soils for cleaning purposes and to prepare parts for painting, plating, repair, inspection, assembly, heat treatment or machining.

Solvent metal cleaning can be divided into three categories: cold cleaning, open top vapor degreasing and conveyorized degreasing.

Cold cleaner operations include spraying, brushing, flushing and immersion of articles in a solvent. The solvent is occasionally heated but always remains well below its boiling point.

The two basic types of cold cleaners are maintenance cleaners and manufacturing cleaners. The maintenance cold cleaners are usually simpler, less expensive and smaller. They are designed principally for automotive and general plant maintenance cleaning. Manufacturing cold cleaners usually give a higher quality of cleaning than maintenance cleaners do, and are thus more specialized. Manufacturing cold cleaning is generally an integral stage in metal working production. There are fewer manufacturing cold cleaners than maintenance cleaners, but the former tend to emit more solvent per unit because of the larger size and workload. Manufacturing cleaners use a wide variety of solvents, whereas maintenance cleaners use mainly petroleum solvents such as mineral spirits (petroleum distillates and Stoddard solvents). Some cold cleaners can serve both maintenance and manufacturing purposes and are thus difficult to classify.

Cold cleaners are estimated to result in the largest total emission of the three categories of degreasers because there are so many of these units (more than 1 million nationally) and because much of the waste solvent that is disposed of is allowed to evaporate.

Open top vapor degreasers clean only one workload at a time. They clean through the condensation of hot solvent vapor on colder metal parts. The condensing solvent both dissolves oils and provides a washing action to clean the parts. The selected solvents boil at much lower temperatures than do the contaminants; thus, the solvent/soil mixture in the degreaser boils to produce an essentially pure solvent vapor. One section of the degreaser is equipped with a heating system that uses steam, electricity or fuel combustion to boil the solvent. As the solvent boils, the dense solvent vapors displace the air within the equipment. The upper level of these pure vapors is controlled by condenser coils which are supplied with a coolant such as water. Nearly all vapor degreasers are equipped with a water separator which allows the water (being immiscible and less dense than solvents) to separate from the solvent and decant from the system while the solvent flows from the bottom of the chamber back into the vapor degreaser.

The third category of degreasers is conveyorized degreasers. There are several types operating both with cold and vaporized solvents. The types of conveyorized degreasers include crossrod, rotating wheels, conveyor belts, and monorails as well as other systems which convey the parts through the degreasing medium.

In conveyorized equipment, most, and sometimes all, of the manual parts handling associated with open top vapor degreasing has been eliminated. Conveyorized degreasers are nearly always hooded or covered. The enclosure of a degreaser diminishes solvent losses from the system as the result of air movement within the plant. Conveyorized degreasers are used by a broad spectrum of metal working industries but are most often found in plants where there is enough production to provide a constant stream of products to be degreased.

The EPA has estimated[1] that about 1.3 million cold cleaners operate in the U.S.; about 70 percent are used in maintenance or service cleaning and 30 percent in manufacturing. There are also an estimated 22,200 open top vapor degreasers and 4,000 vapor conveyorized degreasers. In 1975, estimated emissions in the United States from these cleaners exceeded 700,000 metric tons, making solvent cleaning the fifth largest stationary source of organic emissions.

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[1] Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

As recently as 1974, degreasing operations were exempt from regulation in 16 states, since they rarely emitted more than the 3,000 pounds per day of volatile organic compounds (VOC) which was the regulatory level then in effect in these states. They could also qualify for exemption by the substitution of a solvent not considered to be photochemically active. However, the EPA's current direction is toward positive reduction of all VOC emissions, and the EPA has proposed control technology for solvent metal cleaning operations which can achieve sizeable total VOC emission reduction. This technology involves the use of proper operating practices and the use of retrofit control equipment.

Proper operating practices are those which minimize solvent loss to the atmosphere. These include covering degreasing equipment whenever possible, properly using solvent sprays, employing various means to reduce the amount of solvent carried out of the degreaser on cleaned work, promptly repairing leaking equipment and most important, properly disposing of wastes containing volatile organic solvents.

In addition to proper operating practices, many control devices can be retrofitted to existing degreasers; however, because of the diversity in their designs, not all degreasers require the same type of control devices. Small degreasers using a room temperature solvent may require only a cover, whereas large degreasers using boiling solvent may require a refrigerated freeboard chiller or a carbon adsorption system. Two types of control equipment which will be applicable to many degreaser designs are drainage facilities for cleaned parts and safety switches and thermostats, which prevent large emissions from equipment malfunction. These controls, the types of degreasers to which they can be applied and the expected emission reductions are described later in this chapter.

11.1.2 Method of Estimation of the Number of Degreasers

The number of solvent metal degreasers in Tennessee was determined in three steps. First, the number of degreasers in the three urban counties (Davidson, Hamilton, and Shelby) for which no emissions data were available was estimated. Next, the number of degreasers in the rural counties in which emissions data for those facilities with potential VOC emissions over 100 tons per year for solvent metal degreasing were available, was estimated. Finally, the degreasers in the urban and rural counties were aggregated to obtain the statewide number of degreasers. The methods for estimating the number of degreasers in the urban and rural counties are discussed below.

11.1.2.1 Number of Degreasers in Urban Counties

The number of degreasers in the three urban counties was determined on the basis of a detailed industrywide study of metal degreasing in the U.S., conducted by the Dow Chemical Company under contract to the EPA. The results of the study are reported in: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Contract No. 68-02-1329, June 30, 1976.

The report was based on a telephone survey of more than 2,500 plants in the metal working industry (SIC groups 25, 33, 34, 35, 36, 37, 38 and 39) with more than 19 employees. The report presents estimates of the:

- Percentage of U.S. plants using solvent degreasing
- Percentage of plants using cold cleaners, open top vapor degreasers or conveyorized cleaners
- Average number and type of vapor degreasers used in these plants
- Distribution of these quantities by region.

All of these quantities are further identified by the eight metal working industries. In the report (based on the 1972 Census of Manufactures) 15,294 open top and 2,796 conveyorized vapor degreasers were estimated to be in use in the eight SIC groups; an additional 5,000 to 7,000 open top degreasers were estimated[1] to be in use in 1972 in manufacturing or service firms not included in one of the eight SIC groups or in firms with less than 20 employees.

To determine the number of open top and conveyorized vapor metal degreasers in the three counties, first the number of plants with more than 19 employees in each of the eight SIC groups was determined. The average number of plants using solvent metal degreasing and the average number and type of cleaners used per plant were then obtained by using the factors presented in the Dow report. The results of these calculations and the factors used are tabulated in Exhibit 11-1, on the following page. The total number of open top degreasers was then estimated by multiplying the number expected to be used in the eight metal working SIC groups by the ratio of 22,200/15,200 (the ratio of total open top units in the U.S. to those used in the eight SIC groups in the U.S.).

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[1] Interviews with Parker Johnson, Vice President, Sales, Baron-Blakeslee Corp., Cicero, Illinois and with Richard Clement, Sales Manager, Detrex Chemical, Detroit, Michigan, July 1978.

Because of their expense and function, conveyorized vapor degreasing units are most likely to be used in manufacturing only. Therefore, the total number of these units in the three urban counties was assumed to be the same as that calculated for the eight SIC metal working industries. The total number of conveyorized cleaners, vapor and cold, was then determined by multiplying the number of vapor conveyorized cleaners by 100/85, the EPA[1] estimated ratio of total conveyorized cleaners to vapor conveyorized cleaners in the U.S.

The number of cold cleaners in the three urban counties was based on the Dow estimates of cold cleaning done in plants in the eight SIC metal working industries and the EPA estimate of 1,300,000 cold metal cleaners in the U.S., which include 390,000 in manufacturing use and 910,000 in maintenance or service use.[2] Then:

- The EPA estimates of all cold cleaners in manufacturing use in the U.S. was multiplied by the ratio of the number of plants in the metal working industries (SICs 25 and 33-39) in the three counties to the number in the U.S.

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[1] Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

[2] Cold cleaners in manufacturing use are meant to include only those cleaners employed in the manufacturing process; cold cleaners in maintenance and service use are those employed for this purpose by either manufacturing or service establishments.

EXHIBIT 11-1 (1)
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF VAPOR DEGREASERS IN DAVIDSON, HAMILTON, AND SHELBY COUNTIES IN TENNESSEE

Item	SIC GROUP[a] 25	33	34	35	36	37	38	39	Total
Number of plants with more than 19 employees[b]	33	16	100	68	34	27	8	24	310
Percent of plants using solvent degreasing[c]	44	38	40	50	53	48	62	37	
Number of plants using solvent degreasing	15	6	40	34	18	13	5	9	140
Percent of plants using vapor degreasing[c]	40	35	34	27	55	36	51	46	
Number of plants using vapor degreasing	6	2	14	9	10	6	3	4	54
Average number of vapor degreasers per plant[c]	1.76	1.96	1.44	1.43	1.80	2.88	2.01	0.90	
Number of vapor degreasers	11	4	20	13	18	17	6	4	93
Percent as open top degreasers[c]	67	72	72	74	80	80	86	82	
Number of open top vapor degreasers[d]	8	3	15	10	15	14	5	3	108[e]
Number of conveyorized vapor degreasers[d]	3	1	5	3	3	3	1	1	24[f]

11-6-a

EXHIBIT 11-1 (2)
U.S. Environmental Protection Agency
(Tennessee)

NOTE: All data based on plants with more than 19 employees.

a. The SIC Groups are: 25-Metal Furniture; 33-Primary Metals; 34-Fabricated Products; 35-Non-electrical Machinery; 36-Electrical Equipment; 37-Transportation Equipment; 38-Instruments and Clocks; and 39-Miscellaneous Industry.

b. Source: County Business Patterns, U.S. Department of Commerce, 1976.

c. Source of data on percentage of plants solvent degreasing, those with open top or conveyorized vapor degreasers and average numbers of degreasers per plant: Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations, Dow Chemical Company under EPA Contract 68-02-1329, June 30, 1976.

d. Number of degreasers rounded to the nearest whole integer.

e. To adjust quantities to account for vapor degreasers in other SIC groups multiply by the factor (22,200/15,200), the ratio of all open top vapor degreasers in U.S. to open top vapor degreasers in metal working SIC groups.

f. To adjust quantities to include cold conveyorized cleaners, multiply by 100/85, since conveyorized vapor cleaners are estimated to represent 85 percent of all conveyorized cleaners.

Source: Booz, Allen and Hamilton, Inc.

11-6-b

- The EPA estimates of all cold cleaners in maintenance and service use in the U.S. were multiplied by the ratio of the number of plants in the metal working industries plus selected service industries (SIC codes 551, 554, 557, 7538, 7539, 7964) for the affected areas to the number in the U.S. These service industries are expected to have at least one or more cold cleaners.
  - SIC 551 applies to industries categorized as new or used car dealers.
  - SIC 554 applies to industries categorized as gasoline service stations.
  - SIC 557 applies to industries categorized as motorcycle dealers.
  - SIC 7538 applies to industries categorized as general automotive repair shops.
  - SIC 7539 applies to industries categorized as automotive repair shops, n.e.c.
  - SIC 7694 applies to industries categorized as armature rewinding shops.

The estimates of the total number of cold cleaners in the three counties obtained by these calculations are tabulated in Exhibit 11-2, on the following page.

11.1.2.2 Number of Degreasers in Rural Counties

The number of degreasers in the rural counties was determined on the basis of the total VOC emissions of 1,913 tons per year from solvent metal degreasing from 14 manufacturing facilities as reported by the Tennessee Department of Health, Air Pollution Control Division. These facilities had potential VOC emissions over 100 tons per year from solvent metal degreasing operations and, therefore, were affected by the proposed state VOC control regulation.*

The total VOC emissions were first divided among cold cleaners, open top vapor degreasers, and conveyorized degreasers in the same proportions as those obtained for manufacturing

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* There may be additional facilities potentially affected by the proposed regulation in the rural counties, but this could not be verified because of the lack of data.

EXHIBIT 11-2
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD CLEANERS IN THREE URBAN COUNTIES IN TENNESSEE

	U.S.	Tennessee
Total number of plants in SIC Groups 25,33,34,35,36,37,38,39[a]	125,271	811
Estimated number of cold cleaners in manufacturing[b]	390,000	2,525
Total number of plants in service industries SIC 551,554,557,7538,7539,7694[a]	227,350	1,523
Estimated number of cold cleaners in maintenance and service use[b,c]	910,000	6,023
Estimated total number of cold cleaners[a]	1,300,000	8,548

Notes:

a. Source: 1976 County Business Patterns, U.S. Department of Commerce, 1976.

b. Source: Control of Volatile Organic Emissions From Solvent Metal Cleaning, EPA-450/2-77-022, November 1977.

c. This includes cold cleaners in maintenance and service applications in both manufacturing and repair firms.

Source: Booz, Allen & Hamilton, Inc.

facilities in the three urban counties.[1] These emissions were then divided by the average emissions per degreasers given in Exhibit 11-7, (section 11.2.2) to obtain the number of degreasers in the rural counties.

The number of degreasers estimated from this method represents the average size degreasers. Since, the potentially affected manufacturing facilities in the rural counties are large in size, the degreasers used in these facilities are likely to be larger than the average size, hence fewer in number than the estimate. However, the total cost of compliance estimated on the basis of the greater number of average size degreasers is expected to approximate the cost experienced by fewer but larger facilities.

11.1.3 Method of Estimation of Affected Degreasers

The proposed state regulations provide several exemptions for degreasers based on size, type of solvent used or emission rate.

- Facilities located in the three urban counties with potential emissions less than 25 tons per year are to be exempt. It is estimated that this would exempt approximately 90 percent of the estimated number of cold cleaners in the three urban counties as shown in Exhibit 11-2. It is estimated that 30 manufacturing facilities with an average of 30 cold cleaners per facility would be potentially affected by the proposed regulation based on average emission rates per cold cleaner, average number of cold cleaners per employee and the distribution of employees per facility in these counties.

- Cleaners used exclusively for chemical or physical analysis or determination of product quality and acceptance are to be exempt. Since few such cleaners exist, no correction was made to the estimated number of cleaners used in determining the estimated compliance costs.

- Those cleaners using 1,1,1 trichloroethane and trichlorotrifluoroethane are to be exempt. Estimates of the number of open top degreasers which use either of these solvents range from 35 percent to 60 percent.[2] For the purpose of calculating

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1. The percentages of total VOC emissions from cold cleaners, open top vapor degreasers, and conveyorized degreasers used in manufacturing facilities in the three urban counties were found to be 35.6 percent for cold cleaners and 34.1 percent for open top and 30.3 percent for conveyorized degreasers

2. Based on information in EPA 450/2-77-022, op. cit., and interviews with Baron-Blakeslee and Detrex Chemical personnel.

cost impacts in this study, 35 percent was used. About 10 percent of conveyorized cleaners are expected to be exempt[1] and about 20 percent of cold cleaners.[2]

- Open top vapor degreasers with less than one square meter (10.8 square feet) air/vapor interface and conveyorized degreasers with less than two square meters (21.6 square feet) are to be exempt. This exemption applies to about 30 percent of open top cleaners and 5 percent of conveyorized degreasers.[1]

The guidelines leave open to the degreaser user the option of changing from a nonexempt solvent to an exempt one. In most cases, this will require some modification of the degreaser and an additional expense for the modification. In this study it was assumed that no substitution is made.

No reliable information has been found which relates size of cleaner with solvent composition. Therefore, we have assumed a uniform distribution of solvent composition with cleaner size, i.e., the number of small cleaners using exempt solvents is the same as the number of large cleaners using exempt solvents. For instance, the total of affected open top vapor degreasers in the state was determined by multiplying the total number of open top vapor degreasers in the state by the fractions that are nonexempt by solvent use and by size, i.e.:

Number exempt by size = (Total number of open top degreasers) x (Fraction exempt by size, 0.3)

Number exempt by solvent = (Total number of open top degreasers - number exempt by size) x (Fraction exempt by solvent, 0.35)

Total number of affected (nonexempt) degreasers = (Total number of open top degreasers) - (Number exempt by size) - (Number exempt by solvent)

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[1] Based on information in EPA 450/2-77-022, op. cit., and interviews with Baron-Blakeslee and Detrex Chemical personnel.

[2] Dow report, op. cit.

The resulting estimate of the total number of degreasers in the county and those exempt from the proposed regulations by size and solvent composition are summarized in Exhibit 11-3, in section 11.2.

11.1.4 Method of Estimation of Number and Type of Retrofitted Controls Needed

The proposed regulations specify certain controls which can be retrofitted to existing solvent metal cleaners. These are discussed in detail in a later section of this chapter. Briefly they are:

- For affected cold cleaners
    - A cover must be installed when the solvent used has a volatility greater than 15 millimeters of mercury at 38°C, or is agitated, or the solvent is heated; and
    - An internal drainage facility (or, where that is not possible, an external closed drainage facility) must be installed, such that the cleaned parts drain while covered when the solvent used has a volatility greater than 32 millimeters of mercury at 38°C; and
    - Where the solvent has a volatility greater than 32 millimeters of mercury at 38°C, a freeboard must be installed that gives a freeboard ratio (i.e., distance from cleaner top to solvent surface divided by cleaner width) greater than or equal to 0.7; or a water cover where the solvent is heavier and immiscible or unreactive with water; or some other system of equivalent control.
- For affected open top vapor degreasers--
    - The vapor degreaser must be equipped with a cover; and
    - A spray safety switch must be installed which shuts off the spray pump when the vapor level drops more than 4 inches; and

  - If the freeboard ratio is greater than 0.75, a powered cover must be installed or a refrigerated chiller; or an enclosure in which a cover or door opens only when the dry part is entering or exiting the degreaser; or a carbon adsorption system; or an equivalent control system.

- For affected conveyorized degreasers--
  - A refrigerated chiller; or carbon adsorption system; or another equivalent control system must be installed; and
  - The cleaner must be equipped with a drying tunnel or rotating basket to prevent cleaned parts from carrying out solvent; and
  - A condenser flow switch and thermostat, a spray safety switch and a vapor high level control thermostat must be installed; and
  - Openings must be minimized during operation so that entrances and exits silhouette workloads; and
  - Downtime covers must be provided for closing off the entrance and exit during shutdown hours.

Exhibits 11-14, 11-15 and 11-16 of this chapter summarize estimates of the percentage of non-exempt cleaners needing these controls. Equipment manufacturers were the primary source of the percentages used. In applying this information, it was assumed that the number and type of control needed were independent of size.

11.1.5 Method of Estimation of Current Emissions and Expected Reductions

Current VOC emissions from solvent metal degreasing and the reductions anticipated by the enforcement of the proposed regulations are based on information presented in Control of Volatile Organic Emissions from Solvent Metal Cleaning, EPA-450/2-77-022, November 1977. This report estimates average emissions for each type of degreaser. The total current emissions were obtained by multiplying these estimated average emissions by the number of each type of degreaser in the affected areas of the state.

The report also estimates the reduction in emissions possible by implementation of various types of controls. The methods proposed in recent EPA guidance can result in reduction of 50 percent to 69 percent for various types of degreasers. Emission levels which would result from implementation of the RACT proposals for solvent metal cleaners was obtained by use of these estimated reductions for the number of affected cleaners in the state. For purposes of estimation, a 50 percent reduction was used for cold cleaners. For open top vapor and conveyorized cleaners, a 60 percent reduction was used.

11.1.6 Method of Estimation of Compliance Costs

Compliance costs also were based primarily on the cost data presented in the EPA report, Control of Volatile Organic Emissions from Solvent Metal Cleaning, for average-sized, cold, open top vapor and conveyorized cleaners. These cost data, however, were verified by discussions with equipment manufacturers. Where some costs, such as for safety switches or downtime covers, were not estimated in the report, estimates were made based on further discussions with equipment manufacturers. In the EPA report, costs were presented for various retrofit control options; in each case the control which would provide minimum net annualized costs was used in the estimates made here. Other costs not presented in the EPA report were determined as follows:

- Safety switches, minimizing conveyorized cleaner openings, and downtime cover capital costs were estimated on the basis of discussions with equipment manufacturers. Costs used were:
  - $300 per manual cover and $100 per safety switch installation for open top vapor degreasers
  - $250 per safety switch installation, $300 per downtime cover installation, $2,500 per drying tunnel, and $1,000 for reducing openings for conveyorized cleaners.
- $300 was used as an average cost for increasing freeboard of cold cleaners using high volatility solvents.

- Annual capital charges were estimated as 25 percent of capital costs, to include depreciation, interest, maintenance, insurance and administrative costs.
- Labor costs for mounting downtime covers on conveyorized cleaners at shift end were estimated at $1,500 per year per cleaner.
- Additional costs which might result from decreased productivity, labeling and other requirements of the proposed regulations were assumed to be small and negligible.

11.1.7 Quality of Estimates

Several sources of information were utilized in assessing the emissions, direct compliance cost and economic impact of implementing RACT controls on plants using solvent metal degreasers in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data, "B" indicates data that was not available in secondary literature and was extrapolated from hard data (i.e. data that is published for the base year) and "C" indicates data was estimated based on interviews, analyses of previous studies and best engineering judgement. Exhibit 11-2A, on the following page, rates each study output and overall quality of the data.

EXHIBIT 11-2A
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A "Hard Data"	B "Extrapolated Data"	C "Estimated Data"
Industry statistics	X	X	
Emissions		X	
Cost of emissions control		X	X
Statewide costs of emissions			X
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

11.2 INDUSTRY STATISTICS

This section summarizes an estimation of the total number of solvent metal cleaners affected in the state determined by the methods discussed in section 11.1.2 of this report. A total of 167 open top vapor degreasers, 44 conveyorized degreasers and 10,612 cold cleaners are estimated to be in use in Tennessee in manufacturing, maintenance or service. As discussed earlier, not all of these will be subject to RACT regulations because of size or solvent exemptions. About 30 percent of open top vapor degreasers and 5 percent of conveyorized degreasers are expected to be exempt on the basis of size. Approximately 90 percent of the cold cleaners will be exempt because of the 25 ton or 100 ton potential emission limitations per facility. About 35 percent of open top vapor degreasers, 10 percent of conveyorized degreasers and 20 percent of cold cleaners are expected to be exempt because they use exempt solvents methyl chloroform or Freon 113. Applying these factors results in the total of affected cleaners shown in Exhibit 11-3, on the following page.

It is difficult to estimate the number of establishments affected by the regulations, since a plant may have one or many cleaners of each type. In fact, large-scale users may have more than 100 degreasing operations in one plant location. Metal working industries would be major users; eight SIC codes, 25 and 33-39, cover these industries.

These classifications include such indistries as automotive, electronic, appliances, furniture, jewelry, plumbing, aircraft, refrigeration, business machinery and fasteners. However, use of solvent cleaning is not limited to those industries, since many cleaners are used, for both manufacturing and maintenance, in nonmetal working industries such as printing, chemicals, plastics, rubber, textiles, paper and electric power. Also, most automotive, railroad, bus, aircraft, truck and electric motor repair stations use metal solvent cleaners at least part time.

As discussed in Section 11.1.2, it is estimated that 14 facilities in the rural counties and 310 facilities in the SIC codes 25 and 33-39, with more than 19 employees, in the three urban counties use solvent metal degreasing. However, as shown in Exhibit II-2, in section 11.1.2, there are a total of 811 plants in service industries in the three urban counties; all of these are expected to have some type of solvent degreasers and could be potentially affected.

EXHIBIT 11-3
U.S. Environmental Protection Agency
ESTIMATE OF AFFECTED SOLVENT METAL CLEANERS IN TENNESSEE

	Number of Cleaners by Type		
Exemption	Cold	Open Top Vapor	Conveyorized
Total number of cleaners	10,612	167	44
Number exempt by size	9,712	50	82
Number affected by size	900	117	41
Number further exempted by type of solvent used	180	41	4
Total number of affected cleaners	720	76	38

Source: Booz, Allen & Hamilton Inc.

11.2.1 Proposed Emission Control Systems for Solvent Metal Cleaners

The EPA has proposed two different emission control methods, A and B, for each of the three types of cleaners: cold, open top vapor and conveyorized. The control methods can be combined in various ways to form a number of alternative control systems. Generally, control system A consists of proper operating practices and simple, inexpensive control equipment. Control system B consists of system A plus other devices that increase the effectiveness of control. Elements of control systems A or B can be modified to arrive at the level of control needed. The control systems are presented in the three exhibits, Exhibit 11-4, 5 and 6, on the following pages, and are briefly discussed below. In general, use of control system B has been proposed to maximize emission reductions.

11.2.1.1 Cold Cleaning Control Systems

The most important emission control for cold cleaners is the control of waste solvent. The waste solvent needs to be reclaimed or disposed of so that a minimum evaporates into the atmosphere. Next in importance are the operating practices of closing the cover and draining cleaned parts. Several other control techniques become significant only in a small fraction of applications.

The difference in effect between systems A and B (Exhibit 11-4) is not large because most of the cold cleaning emissions are controlled in system A. If the requirements of system A were followed conscientiously by nearly all of the cold cleaning operators, there would be little need for the additional system B requirements. However, because cold cleaning operators tend to be lax in keeping the cover closed, equipment requirements #1 and #4 in system B are added. Similarly, the modifications for #2 and the equipment requirements in #3 would effect significant emission reductions in a few applications.

The effectiveness of the control systems depends greatly on the quality of operation. On the average, system A is estimated to be able to reduce cold cleaning emissions by 50 (± 20) percent and system B may reduce it by 53 (± 20) percent. The low end of the range represents the emission reduction projected for poor compliance, and the high end represents excellent compliance. The expected benefit from system B is only slightly better than that for

EXHIBIT 11-4
U.S. Environmental Protection Agency
CONTROL SYSTEMS FOR COLD CLEANING

Control System A

Control Equipment:

1. Cover
2. Facility for draining cleaned parts
3. Permanent, conspicuous label, summarizing the operating requirements

Operating Requirements:

1. Do not dispose of waste solvent or transfer it to another party, such as that greater than 20 percent of the waste (by weight) can evaporate into the atmosphere.* Store waste solvent only in covered containers.

2. Close degreaser cover whenever not handling parts in the cleaner.

3. Drain cleaned parts for at least 15 seconds or until dripping ceases.

Control System B

Control Equipment:

1. Cover: Same as in System A, except if (a) solvent volatility is greater than 2 Kpa (15 mm Hg or 0.3 psi) measured at 38°C (100°F),** (b) solvent is agitated, or (c) solvent is heated, then the cover must be designed so that it can be easily operated with one hand. (Covers for larger degreasers may require mechanical assistance, by spring loading, counterweighting or powered systems.)

2. Drainage facility: Same as in System A, except that if solvent volatility is greater than about 4.3 Kpa (32 mm Hg or 0.6 psi) measured at 38°C (100°F), then the drainage facility must be internal, so that parts are enclosed under the cover while draining. The drainage facility may be external for applications where an internal type cannot fit into the cleaning system.

3. Label: Same as in System A

4. If used, the solvent spray must be solid, fluid stream (not a fine, atomized or shower type spray) and at a pressure which does not cause excessive splashing.

5. Major control device for highly volatile solvents: If the solvent volatility is 4.3 Kpa (33 mm Hg or 0.6 psi) measured at 38 C (100 F), or if solvent is heated about 50 C (120 F), then one of the following control devices must be used:

   a. Freeboard that gives a freeboard ratio*** 0.7

   b. Water cover (solvent must be insoluble in and heavier than water)

   c. Other systems of equivalent control, such as refrigerated chiller or carbon absorption.

Operating Requirements:

Same as in System A

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* Water and solid waste regulations must also be complied with

** Generally solvents consisting primarily of mineral spirits (Stoddard) have volatilities 2 Kpa.

*** Freeboard ratio is defined as the freeboard height divided by the width of the degreaser.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-5(1)
U.S. Environmental Protection Agency
EPA PROPOSED CONTROL SYSTEMS FOR OPEN TOP VAPOR DEGREASERS

Control System A

Control Equipment:

1. Cover that can be opened and closed easily without disturbing the vapor zone.

Operating Requirements:

1. Keep cover closed at all times except when processing work loads through the degreaser.

2. Minimize solvent carry-out by the following measures:

a. Rack parts to allow full drainage.
b. Move parts in and out of the degreaser at less than 3.3 m/sec (11 ft/min).
c. Degrease the work load in the vapor zone at aleast 30 sec. or until condensation ceases.
d. Tip out any pools of solvent on the cleaned parts before removal.
e. Allow parts to dry within the degreaser for at least 15 sec. or until visually dry.

3. Do not degrease porous or absorbent materials, such as cloth, leather, wood or rope.

4. Work loads should not occupy more than half of the degreaser's open top area.

5. The vapor level should not drop more than 10 cm (4 in) when the work load enters the vapor zone.

6. Never spray above the vapor level.

7. Repair solvent leaks immediately, or shut down the degreaser.

8. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waste (by weight) will evaporate into the atmosphere. Store waste solvent only in closed containers.

9. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser open area, unless necessary to meet OSHA requirements. Ventilation fans should not be near the degreaser opening.

10. Water should not be visually detectable in solvent exiting the water separator.

Control System B

Control Equipment:

1. Cover (same as in system A).

2. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if condenser coolant is either not circulating or too warm).

b. Spray safety switch - shuts off spray pump if the vapor level drops excessively, about 10 cm (4 in).

EXHIBIT 11-5 (2)
U.S. Environmental Protection Agency

3. Major Control Device:

Either: a. Freeboard ratio greater than or equal to 0.75, and if the degreaser opening is $1m^2$ (10 ft^2), the cover must be powered,

b. Refrigerated chiller,

c. Enclosed design (cover or door opens only when the dry part is actually entering or exiting the degreaser),

d. Carbon adsorption system, with ventilation 15 m^3/min per m2 (50 cfm/ft^2) or air/vapor area (when cover is open), and exhausting 25 ppm solvent averaged over one complete adsorption cycle, or

e. Control system, demonstrated to have control efficiency, equivalent to or better than any of the above.

4. Permanent, conspicuous label, summarizing operating procedures #1 to #6.

Operating Requirements:

Same as in System A.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-6
U.S. Environmental Protection Agency
EPA PROPOSED CONTROL SYSTEMS FOR CONVEYORIZED DEGREASERS

Control System A

Control Equipment: None

Operating Requirements:

1. Exhaust ventilation should not exceed 20 m^3/min per m^2 (65 cfm per ft^2) of degreaser opening, unless necessary to meet OSHA requirements. Work place fans should not be used near the degreaser opening.

2. Minimize carry-out emissions by:

a. Racking parts for best drainage.
b. Maintaining verticle conveyor speed at 3.3 m/min (11 ft/min).

3. Do not dispose of waste solvent or transfer it to another party such that greater than 20 percent of the waster (by weight) can evaporate into the atmosphere. Store waste solvent only in covered containers.

4. Repair solvent leaks immediately, or shut down the degreaser.

5. Water should not be visibly detectable in the solvent exiting the water separator.

Control System B

1. Major control devices; the degreaser must be controlled by either:

a. Refrigerated chiller,
b. Carbon adsorption system, with ventilation 15 m^2/min per m^2 (50 cfm/ft^2) of air/vapor area (when down-time covers are open), and exhausting 25 ppm of solvent by volume averaged over a complete adsorption cycle, or
c. System demonstrated to have control efficiency equivalent to or better than either of the above.

2. Either a drying tunnel, or another means such as rotating (tumbling) basket, sufficient to prevent cleaned parts from carrying out solvent liquid or vapor.

3. Safety switches

a. Condenser flow switch and thermostat - (shuts off sump heat if coolant is either not circulating or too warm).
b. Spray safety switch - (shuts off spray pump or cenveyor if the vapor level drops excessively, e.g. 10 cm (4 in.)).
c. Vapor level control thermostat - (shuts off sump heat when vapor level rises too high).

4. Minimized openings: Entrances and exits should silhouette work loads so that the average clearance (between parts and the edge of the degreaser opening) is either 10 cm (4 in.) or 10 percent of the width of the opening.

5. Down-time covers: Covers should be provided for closing off the entrance and exit during shutdown hours.

Operating Requirements:

1. to 5. Same as the System A

6. Down-time cover must be placed over entrances and exits of conveyorized degreasers immediately after the conveyor and exhaust are shut down and removed just before they are started up.

Source: EPA-450/2-77-022, op. cit.

system A for an average cold cleaner because the additional devices required in system B generally control only bath evaporation, about 20 to 30 percent of the total emission from an average cold cleaner. For cold cleaners with high volatility solvents, bath evaporation may contribute about 50 percent of the total emission; EPA estimates that system B could achieve 69 (± 20) percent control efficiency, whereas system A might achieve only 55 (± 20) percent.

11.2.1.2 Open Top Vapor Degreasing Control Systems

The basic elements of a control system for open top vapor degreasers are proper operating practices and use of control equipment. There are about ten main operating practices. The control equipment includes a cover, safety switches and a major control device, either high freeboard, refrigerated chiller, enclosed design or carbon adsorption as outlined in Exhibit 11-5.

A vapor level thermostat is not included because it is already required by OSHA on "open surface vapor degreasing tanks." Sump thermostats and solvent level controls are used primarily to prevent solvent degradation and protect the equipment and thus are also not included here. The emission reduction by these controls is a secondary effect in any event. The two safety switches serve primarily to reduce vapor solvent emissions.

EPA estimates that system A may reduce open top vapor degreasing emissions by 45 (± 15) percent, and system B by 60 (± 15) percent. For an average-sized open top vapor degreaser, systems A and B would reduce emissions from 9.5 m tons/year down to about 5.0 and 3.8 m tons/year, respectively. It is clear that system B is appreciably more effective than system A.

11.2.1.3 Conveyorized Degreasing Control Systems

Control devices tend to work most effectively on conveyorized degreasers, mainly because they are enclosed. Since these control devices can usually result in solvent savings, they often will net an annualized profit. Two control systems for conveyorized degreasers as recommended by EPA are shown in Exhibit 11-6. Control system A requires only proper operating procedures which can be implemented, in most cases, without large capital expenditures. Control system B, on the other hand, requires a major control device.

Major control devices can provide effective and economical control for conveyorized degreasers. A refrigerated chiller will tend to have a high control efficiency, because room drafts generally do not disturb the cold air blanket. A carbon adsorber also tends to yield a high control efficiency, because collection systems are more effective and inlet streams contain higher solvent concentrations for conveyorized degreasers than for open top vapor degreasers.

11.2.2 Emissions and Expected Emission Reduction

In Exhibit 11-7, on the following page, are summarized the average emissions from solvent metal degreasers by type and also the percent emission reduction expected by implementation of Type B method of controls on nonexempt degreasers. The levels are based on estimated emissions as presented in the previously referenced EPA report (EPA 450/2-77-022) and represent current average emission levels and expected reductions achievable if emission controls are rigorously enforced. For estimation, 50 percent reduction was used for cold cleaners and 60 percent for open top vapor and conveyorized degreasers.

Exhibit 11-8, following Exhibit 11-7, presents the estimated current emissions from solvent metal degreasing and the expected emissions if the B methods of control are implemented for metal cleaners and proposed exemptions for size and type of solvent are implemented. As shown, emissions are expected to be reduced from about 6,646 short tons per year to a total of 5,348 short tons per year. The major portion of these reduced emissions, 443 tons, are from solvent metal cleaners exempt from the proposed RACT regulations either by size or by the nature of solvent used. Implementation of the regulations will reduce emissions by 1,298 tons per year.

EXHIBIT 11-7
U.S. Environmental Protection Agency
AVERAGE UNIT EMISSION RATES AND EXPECTED EMISSION REDUCTIONS

EMISSION RATES WITHOUT CONTROLS

Type of Degreaser	Averaged Emission Rate Per Unit (short tons/yr.)
Cold cleaners, batch [a]	0.33
Open top vapor degreaser	11.00
Conveyorized degreaser	29.70

PERCENT EMISSION REDUCTION EXPECTED WITH TYPE B CONTROLS

Type of Degreaser	Percent Emission Reduction Expected
Cold cleaner, batch	
Low volatility solvents	53 (± 20)
High volatility solvents	69 (± 20)
Open top vapor degreaser	60 (± 15)
Conveyorized degreaser	60 (± 15)

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[a] Does not include emissions from conveyorized-type cold cleaners which represent about 15 percent of all conveyorized cleaners.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-8
U.S. Environmental Protection Agency
ESTIMATED CURRENT AND REDUCED EMISSIONS FROM SOLVENT METAL CLEANING IN TENNESSEE

Type of Cleaner	Estimated Current Emissions	Estimated from Nonexempt Cleaners After RACT	Estimated Emissions From Exempt Cleaners After RACT[a]	Estimated Total Emissions After RACT[a]
Open top vapor	1,837	335	1,001	1,336
Conveyorized	1,307	451	178	629
Cold	3,502	119	3.264	3.383
Total	6,646	905	4,443	5,348

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a. Includes emissions from cleaners exempt by size or using 1,1,1-trichloroethane or Freon 113

Source: Booz, Allen & Hamilton Inc.

11.3 ESTIMATED COSTS OF RACT IMPLEMENTATION

As discussed in Section 11.1.6 compliance costs are based upon EPA estimates of the costs and benefits of various retrofitted methods of control. These estimates are summarized in Exhibits 11-9 and 11-10, on the following pages.

Costs of implementation of the RACT regulations are summarized in Exhibits 11-11, 11-12 and 11-13 on the assumption that control methods B are used to maximize emission reduction on nonexempt cleaners. Exhibits 11-14, 11-15, and 11-16 summarize the number and type of controls needed by cleaner type as determined from interviews with cleaner manufacturers. Total expenditures for all cleaners, vapor and cold types, are estimated to be about $0.9 million in capital and about $70 thousand in net annualized costs. The low net annualized costs result primarily from the savings in solvent use which the regulations are expected to provide.

In no case are the regulations expected to present a severe financial burden to individual firms. The largest single expenditure would be for retrofitting a monorail conveyorized degreaser with chiller, switches, drying tunnel, reduced openings and downtime covers. Total cost for an average-sized degreaser of about 3.8 square meters area (40.9 ft^2) would be less than $12,500. A large unit, 14 square meters, would cost about $27,000 to $30,000. Since these conveyorized systems would only be used in large plants with large sales volumes, this implementation cost is not expected to present a hardship to any particular firm.

EXHIBIT 11-9
U.S. Environmental Protection Agency
CONTROL COSTS FOR COLD CLEANER
WITH 5.25 ft.^{2} AREA

Item	Low Volatility Solvent[a]	High Volatility Solvent[b]
Installed capital ($)	25.00	365.00
Direct operating costs ($/yr.)	1.00	2.6
Capital related charges ($/yr.)	4.30	91.25
Solvent cost (credit) ($/yr.)	(4.80)	(39.36)
Annualized cost (credit) ($/yr.)	0.50	54.49

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a. Costs include only a drainage facility for low volatility solvents.

b. Includes $65 for drainage facility, a mechanically assisted cover, and $300 for extension of freeboard.

c. Capital charges used in study estimate were 25 percent of capital instead of 17 percent used in EPA report.

Source: EPA-450/2-77-022, op. cit.

EXHIBIT 11-10
U.S. Environmental Protection Agency
CONTROL COSTS FOR AVERAGE-SIZED
OPEN TOP VAPOR AND CONVEYORIZED CLEANERS

1. CONTROL COSTS FOR TYPICAL SIZE OPEN TOP VAPOR DEGREASER
(Vapor to Air Area of 1.67 m^2)

Control Technique	Manual Cover	Carbon Adsorption[a]	Refrigerated Chiller	Extended Freeboard & Powered Cover
Installed capital ($)	300	10,300	6,500	8,000
Direct operating cost ($/yr.)	10	451	259	100
Capital related charges ($/yr.)	75	2,575	1,625	2,000
Solvent cost (credit) ($/yr.)	(860)	(1,419)	(1,290)	(1,161)
Net annualized cost (credit) ($/yr.)	(775)	1,607	594	939

2. CONTROL COSTS FOR TYPICAL CONVEYORIZED DEGREASERS
(Vapor to Air Vapor Area of 3.8 m^2)

	Monorail Degreaser		Crossrod Degreaser	
Control Technique	Carbon[a] Adsorber	Refrigerated Chiller	Carbon[a] Adsorber	Refrigerated Chiller
Installed capital (4)	17,600	8,550	17,600	7,460
Direct operating costs ($/yr.)	970	430	754	334
Capital related charges ($/yr.)				
Capital charges ($/yr.)	4,400	2,138	4,400	1,865
Solvent cost (credit) ($/yr.)	(5,633)	(5,633)	(2,258)	(2,258)
Annualized cost (credit) ($/yr.)	(263)	(3,065)	2,896	(59)

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a. Not used in cost estimates since net annualized costs for carbon absorption are the highest for any control method.

b. Capital charges used in study estimate were 25 percent of capital instead of 17 percent used by EPA source.

Source: EPA 450/2-77-022, op. cit.

EXHIBIT 11-11
U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR COLD CLEANERS FOR THE STATE OF TENNESSEE

1. CAPITAL COSTS

Item	Number of Degreasers Needing Conversion	Costs
Capital	490	$166,610

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 1,216
Capital related charges	41,581
Solvent cost	(18,042)
Net annualized costs	$24,756

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-12

U.S. Environmental Protection Agency

ESTIMATED CONTROL COSTS FOR OPEN TOP VAPOR DEGREASERS FOR THE STATE OF TENNESSEE

1. CAPITAL COSTS

Item	Cost
Safety switches	$ 1,500
Powered covers	368,000
Manual covers	6,900
Total	$376,400

2. ANNUALIZED COSTS

Item	Cost
Direct operating costs	$ 4,830
Capital related charges	94,100
Solvent cost	(73,186)
Net annualized costs	$ 25,744

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-13

U.S. Environmental Protection Agency
ESTIMATED CONTROL COSTS FOR CONVEYORIZED DEGREASERS FOR THE STATE OF TENNESSEE

1. CAPITAL COSTS

Item	Costs
Refrigerator chiller	
Monorail degreasers	$119,700
Crossrod degreasers	156,660
Safety switches	2,000
Drying tunnel	10,000
Reduce openings	34,000
Downtime covers	10,200
Total	$332,560

2. ANNUALIZED COSTS

Item	Costs
Direct operating costs	$ 64,034
Capital related charges	83,140
Solvent cost	(126,280)
Net annualized cost	$ 20,894

Source: Booz, Allen & Hamilton, Inc.

EXHIBIT 11-14
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF COLD CLEANERS NEEDING CONTROLS IN THE STATE OF TENNESSEE

Type of Control	Estimated Percent of Cleaners Needing Control	Estimated Number of Cleaners[c] Needing Control
Drainage Facility[a]	5	36
Freeboard and[b] Drainage	63	454

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a. Based on 10 percent of cleaners using low volatility solvents and half of these needing drainage facilities.

b. Based on 90 percent of cleaners using high volatility solvents and 70 percent of these needing additional freeboard and drainage.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 11-15

U.S. Environmental Protection Agency
ESTIMATED NUMBER OF OPEN TOP VAPOR DEGREASERS NEEDING CONTROL IN THE STATE OF TENNESSEE

Type of Control	Estimated Percent of Cleaners Needing Control	Estimated Number of Cleaners Needing Control
Manual covers	30	23
Safety switches	20	15
Powered cover	60	46

Source: Booz, Allen & Hamilton Inc.

11-19-9

EXHIBIT 11-16
U.S. Environmental Protection Agency
ESTIMATED NUMBER OF CONVEYORIZED DEGREASERS NEEDING CONTROLS IN THE STATE OF TENNESSEE

Type of Control	Percent of Cleaners Needing Control	Number of Cleaners Needing Control
Refrigerated chillers for monorail and miscellaneous type cleaners[a]	36	14
Refrigerated chillers for crossrod type cleaners	54	21
Safety switches	20	8
Drying tunnel	10	4
Minimized openings	90	34
Downtime covers	90	34

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[a] Refrigerated chillers were estimated to be needed only on about 90 percent of all conveyorized vapor degreasers; thus, the percent of units needed by monorail-miscellaneous and crossrod types add only to 90 percent.

Source: Booz, Allen & Hamilton Inc.

11.4 DIRECT ECONOMIC IMPLICATIONS

11.4.1 Time Required To Implement Proposed RACT Regulations

Because many degreasers are affected under the proposed regulation (76 open top vapor degreasers, 38 conveyorized degreasers and 720 cold cleaners in Tennessee alone) and because each requires retrofitting of a control device, some users may not be able to comply within proposed compliance schedules because of lack of equipment availability. Discussions with personnel from the major manufacturers of vapor and cold degreasers reveal that none are prepared to provide the necessary controls in quantities to meet a cumulative U.S.-wide demand. Some cleaners could be converted to 1,1,1-trichloroethane and thus become exempt. In fact, many metal solvent cleaners have been converted to trichloroethane in the last few years in anticipation of RACT regulations. However, not all existing machines can be converted because of inadequate condensing sections or improper materials of construction. Trichloroethane can be extremely corrosive if stabilizers are insufficiently replenished. In fact, stainless steel vapor degreasers using 1,1,1-trichloroethane have been reported to fail because of corrosion following the loss of stabilizer.

11.4.2 Effect of Compliance Upon Selected Economic Indicators

Implementation of the proposed regulations is expected to have a negligible effect on Tennessee's statewide economy. Low capital and annual operating costs required by the solvent metal cleaner owners in meeting the proposed regulations are responsible for this minimal impact.

For example, Tennesssee's estimated total capital expenditures in non-attainment counties for SIC groups 25 and 33-39 exceed $280 million for 1976. Total capital expenditures for retrofitting are estimated to be $0.9 million for all SIC groups in the state, less than one percent of total capital expenditures for state.

Similarly implementation will have a negligible impact on total shipments, prices and the state economy as a whole. The total net annualized costs of the proposed regulations ($0.07 million) are negligible compared to the estimated 1976 total shipments of $8.4 billion in SIC groups 25 and

33-39 for state. Considering that these expenditures are spread over service industries and other industries not included in SIC's 25 and 33-39, the overall economic impact is even less significant.

Although solvent metal cleaners are particular to certain industries the proposed regulations are expected to not have an impact on the structure of the state industry. This is due to the dispersion of solvent metal cleaners over many industries and the minimal importance of solvent metal cleaning to the manufacturing processes.

Implementation of the regulations will reduce demand for metal cleaning solvents. This would result in a reduction in solvent sales of about $0.2 million annually which may result in a loss of employment for firms supplying metal cleaning solvents.

11.4.3 Effect of Compliance Upon Energy Consumption

Carbon adsorbers, refrigerated chillers and distillation units are the principal energy consuming control devices used for controlling degreasing emissions. The refrigerated chiller, which would probably be the preferred method of control for conveyorized degreasers because of its low capital and operating costs, will increase a degreaser's energy consumption by about 5 percent. The EPA has estimated consumption of 0.5 kw to 5.0 kw by a chiller, used on a typical conveyorized degreaser of about 3.8m^2 size. About 90 percent or 35 of these currently do not have chillers. Assuming 2,250 hours per year operation, total additional energy consumption annually would be about 39,400 kw-hours to 394,000 kw-hours. This is equal to $1,575 to $15,750 per year in additional power costs, at a cost of $0.04 per kw-hour. Most of this cost is recovered by savings in solvent use. A portion of the increase in energy consumption will be offset by reduced production and consumption of solvents; production because it takes energy to produce solvents and consumption because there is embodied energy in feedstocks such as petroleum distillates.

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[1] EPA-450/2-77-022, op. cit.

11.5 SELECTED SECONDARY ECONOMIC IMPACTS

Implementation is also expected to have minor, if not negligible, impact upon other factors, such as employment, market structure and productivity. The proposed regulations include some change in work practices which will decrease productivity in the metal cleaning operation by 5 percent to 10 percent. Since metal cleaning is normally a minor step in the manufacturing or service process, any change in productivity and employment in user plants is expected to be insignificant.

There will, however, be some temporary increase in employment by those firms manufacturing such components as refrigeration chillers and drying tunnels, that may be required for retrofit controls. No estimates have been made because manufacturers of such components are located throughout the country. This temporary increase, however, may be balanced by a slight decrease in employment occurring because of lower solvent consumption. The decrease would occur primarily in shipping and repackaging operations.

The implementation of the RACT guidelines should not have any major effect on the current market structure of the industries using solvent metal cleaning. Cleaners requiring highest retrofitting costs (i.e., for conveyorized cleaners) are generally owned by large firms. Smaller firms would be expected to have only cold cleaners or open top vapor degreasers. The highest capital costs would be for an open top unit which would require an expenditure of $8,000 or less to comply. This is not expected to be a significant financial burden even to small-sized firms.

* * * *

Exhibit 11-17, on the following page, summarizes the conclusions presented in this report.

EXHIBIT 11-17(1)
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR SOLVENT METAL DEGREASING IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected cleaners	834 cleaners
Indication of relative importance of industrial section to state economy	Value of shipments of firms in SIC groups affected is 8.4 billion.
Current industry technology trends	Where technically feasible, firms are substituting exempt solvents
1977 VOC emissions (actual)	6,646 tons/year (including solvents classified as exempt)
Industry preferred method of VOC control to meet RACT guidelines	Substitution. Otherwise lowest cost option as specified by EPA will be used.
Assumed method of VOC control to meet RACT guidelines	Equipment modifications as specified by the RACT guidelines

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$0.9 million
Annualized cost (statewide)	$70,000 million (less than percent of the 1977 affected facilities' value of shipments)
Price	Metal cleaning is only a fraction of manufacturing costs; price effect expected to be less than 0.005 percent for affected facilities.
Energy	Less than 300 equivalent barrels of oil per year increase
Productivity	5-10 percent decrease for manually operated degreasers. Will not effect conveyorized cleaners.

EXHIBIT 11-17(2)
U.S. Environmental Protection Agency

Affected Areas in Meeting RACT	Discussion
Employment	No effect except a possible slight decrease in firms supplying metal degreasing solvents
Market structure	No change
RACT timing requirements (1982)	Equipment availability--only a few companies now supply the recommended control modifications
Problem areas	No significant problem areas seen. Most firms will be able to absorb cost.
VOC emission after RACT control	5,348 tons/year (80 percent of 1977 VOC emission level--however, this does not include emission controls for exempt solvents)
Cost-effectiveness of RACT control	$55 annualized cost per ton of emissions reduced

Source: Booz, Allen & Hamilton Inc.

BIBLIOGRAPHY

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U.S. Department of Commerce, Census of Manufactures, 1972

U.S. Environmental Protection Agency, Control of Volatile Organic Emissions from Solvent Metal Cleaning EPA-450/2-77-022, November 1977.

U.S. Environmental Protection Agency, Regulatory Guidance for Control of Volatile Organic Emissions from 15 Categories of Stationary Sources EPA-905/2-78-001, April 1978.

Dow Chemical Company, Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations EPA Contract 68-02-1329, June 30, 1976

Private conversations with the following:

Dextrex Chemical Company, Detroit, Michigan
Ethyl Corporation, Baton Rouge, Louisiana
DuPont, Wilmington, Delaware
Dow Chemical Company, Midland, Michigan
PPG, Pittsburgh, Pennsylvania
Allied Chemical Company, Morristown, New Jersey
R.R. Street, Detroit, Michigan
Baron-Blakeslee Corporation, Cicero, Illinois
Hercules Inc., Wilmington, Delaware
Texas Eastman, Longview, Texas

12.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR CONTROL OF REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT controls of refinery vacuum producing systems, wastewater separators and process unit turnarounds in the State of Tennessee. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of refineries, interviews and analysis.

12.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for control of refinery vacuum producing systems, wastewater separators and process unit turnarounds in the State of Tennessee.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

12.1.1 Industry Statistics

Industry statistics on refineries were obtained from several sources. All data were converted to a base year, 1977, based on the following methodologies:

- The number of refineries for 1977 was obtained from the National Petroleum News Factbook, 1978.

- The number of employees in 1977 was obtained from interviews with refinery operators.

- The crude oil operating capacity in barrels per day was obtained from the National Petroleum News Factbook, 1978.

- Value of shipments was estimated based on a value of refined product of $13.95 per barrel. This price was obtained from the National Petroleum News Factbook, 1977.

12.1.2 VOC Emissions

Uncontrolled emissions from wastewater separators and process unit turnarounds were estimated using factors from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. Uncontrolled emissions from vacuum producing systems were estimated using Revision of Evaporative Hydrocarbon Emission Factors, EPA-450/3-76-039.

12.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from refinery vacuum producing systems, wastewater separators and process unit turnarounds are described in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. These data provide the alternatives available for controlling VOC emissions from these refinery operations. Several studies of VOC emission control were also analyzed in detail; and petroleum trade associations, refinery operators and vapor control equipment manufacturers were interviewed to ascertain the most likely types of control processes which would be used in refineries in Tennessee. The specific studies analyzed were: Human Exposures to Atmospheric Emissions from Refineries, American Petroleum Institute, July 1973; and Economic Impact of EPA's Regulations on the Petroleum Refining Industry.

The alternative types of vapor control equipment likely to be applied to refinery vacuum producing systems, wastewater separators and process unit turnarounds were described, and percentage reductions from using each type of control were determined. The methodology for the cost analysis based on this scheme is described in the following paragraphs.

12.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used
- Developing installed capital costs for each control system
- Determining installed capital costs to the refinery in Tennessee.

- Developing additional costs including:
  - Direct operating costs
  - Annualized capital charges
  - Petroleum credit
  - Net annualized cost

Costs were determined from analyses of the following previous studies:

- Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA 450/2-77-025
- Hydrocarbon Emissions from Refineries, American Petroleum Institute, October 1977

and from interviews with petroleum marketers' associations, refinery operators, major oil companies and vapor control equipment manufacturers.

It was found that the refinery in Tennessee has controlled the vacuum producing systems and the process units, but has not controlled the wastewater separation area.

12.1.5 Economic Impacts

The economic impacts were determined by analyzing the leadtime requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Tennessee.

12.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT controls on selected refinery operations in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 12-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 12-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	●		
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

12.2 INDUSTRY STATISTICS

Industry facilities, statistics and business trends for the refinery in Tennessee are presented in this section. The discussion includes a description of the facilities and their characteristics, a comparison of the size of the refining industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from selected refinery operations.

12.2.1 Size of the Industry

There is one refinery in Tennessee, listed in Exhibit 12-2, on the following page, along with location, crude capacity and vacuum distillation capacity. The statewide employment, output, and estimated value of shipments for the Tennessee refinery are displayed in Exhibit 12-3, following Exhibit 12-2.

12.2.2 Comparison of the Industry to the State Economy

In this section the refining industry is compared to the economy of the State of Tennessee by comparing industry statistics to state economic indicators. Employees in the refining industry represent approximately 0.01 percent of the total state civilian labor force of Tennessee. The value of refined products from the Tennessee refinery represents approximately 1.2 percent of the total value of wholesale trade in Tennessee in 1977.

12.2.3 Industry Trends

Petroleum refining is the third largest industry in the United States. Until the 1970s the output of the refining industry had grown at a steady rate. Currently, approximately 280 refineries are owned by approximately 140 firms, located in 40 of the 50 states, Guam, Puerto Rico and the Virgin Islands. The refining industry manufactures hundreds of distinguishably different products, which may be grouped into four broad product classes: gasoline, middle distillates, residual and other.

Exhibit 12-2
U.S. Environmental Protection Agency
PETROLEUM REFINERIES IN TENNESSEE

Name of Firm	Location	Crude Capacity (000, barrels per day)
Delta Refinery Company	Memphis	43.9

Source: National Petroleum News Factbook, 1978.

Exhibit 12-3

U.S. Environmental Protection Agency

INDUSTRY STATISTICS FOR REFINERIES IN TENNESSEE

Establishments	Employees	Output (000, barrels per day)	Yearly Value of Shipments ($ Million, 1977)
1	200[a]	38,000[a]	181[b]

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[a] Based on interview with the plant supervisor, Mr. Red Holcher

[b] Assumes a value of $13.95 per barrel as average for 1977 (Source: National Petroleum News Factbook, 1977)

Source: Booz, Allen & Hamilton Inc.

The bulk of refining is done by firms which also market refined products or produce crude oil or both.

Foreign, Federal, state and local governments all influence the oil product market in terms of taxes, price controls, tariffs on imports of crude oil and products. Foreign crude oil prices had, until 1973, been lower than prices for domestic crude oil. Since the advent of the OPEC cartel in 1975, imported crude oil prices have risen sharply.

12.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on refinery operation, estimated VOC emissions from selected refinery operations in Tennessee, the extent of current control in use, the requirements of vapor control under RACT and the likely RACT alternatives which may be used for controlling VOC emissions from selected refinery operations in Tennessee.

12.3.1 Refinery Operations

The refinery operations considered in this report are:

- Vacuum producing systems
- Wastewater separators
- Process unit turnarounds.

The emissions from these sources vary from one petroleum refinery to another depending on such factors as refinery size and age, crude type, processing complexity, application of control measures and degree of maintenance. Refinery facilities and operations are described in detail in Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025.

12.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from selected refinery operations in Tennessee in 1977. It is assumed that controls have been implemented for vacuum producing systems and process unit turnarounds but that no controls have been implemented for the wastewater separators in the one refinery in Tennessee. Exhibit 12-4, on the following page, shows total estimated emissions from the refinery in Tennessee along with estimated emissions at the complete level of control.

Emissions were estimated based on EPA emission factors reported by U.S. EPA. The EPA is currently updating emission factors based on a new analysis of previous test data. EPA reports the emission factors may change as a result of their ongoing program; therefore, caution must be exercised in using these uncertain emission factors in Tennessee.

Exhibit 12-4

U.S Environmental Protection Agency

ESTIMATED HYDROCARBON EMISSIONS FROM SELECTED REFINERY OPERATIONS IN TENNESSEE

Number of Refineries		Estimated Hydrocarbon Emissions (TPY) With Control[a]	At Complete Control[b]
1	Vacuum Producing Systems	Negligible	Negligible
	Wastewater Separators	641	32
	Process Unit Turnarounds	232	232
	TOTAL	873	264

---

[a] Emissions are estimated using factors from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025. Emissions from vacuum producing systems were estimated using Revision of Evaporative Hydrocarbon Emissions Factors, EPA-450/3-76-039.

[b] Assumes 95 percent recoveries.

12.3.6 RACT Guidelines

The RACT guidelines for VOC emission control from vacuum producing systems, wastewater separators and process unit turnarounds require the following control systems:

- Vacuum producing units—The control measure for vacuum producing units is to vent the noncondensable hydrocarbon stream to a flare or to the refinery fuel gas system
- Wastewater separators—The control measure for emissions from wastewater separators is to cover the separators. Emissions are collected and sent to the flare or refinery fuel gas system.
- Process unit turnarounds—Process unit turnaround emissions are controlled by piping emissions to a flare or to the refinery fuel gas system.

Proper operation and maintenance of equipment will also reduce emissions from cracks and leaks in the system.

12.3.7 Selection of the Most Likely RACT Alternatives

The techniques for the control of VOC emissions from refinery vacuum producing systems, wastewater separators and process unit turnarounds are discussed in detail in this section.

12.3.5.1 Controlling Emissions from Vacuum Producing Units

Steam ejectors with contact condensers, steam ejectors with surface condensers, and mechanical vacuum pumps all discharge a stream of noncondensable VOC while generating the vacuum. Steam ejectors with contact condensers also have potential VOC emissions from their hot wells. VOC emissions from vacuum producing systems can be prevented by piping the noncondensable vapors to an appropriate fire box or incinerator or (if spare compressor capability is available) by compressing the vapors and adding them to refinery fuel gas. The hot wells associated with contact condensers can be covered and the vapors incinerated. Controlling vacuum producing systems in this manner will result in negligible emissions of hydrocarbons from this source. Such systems are now in commercial operation and have been retrofitted in existing refineries. For purposes of this report it is assumed that recovered VOC are used in the refinery fuel gas system, thus creating a credit in cost for recovered petroleum.

12.3.7.2 Controlling Emissions from Wastewater Separators

Reasonable control of VOC emissions from wastewater separators consists of covering the forebays and separator sections, thus minimizing the amount of oily water exposed to atmosphere. Commercially operating systems include a solid cover with all openings sealed, totally enclosing the compartment liquid contents, or a floating pontoon or double-deck type cover, equipped with closure seals to enclose any space between the cover's edge and compartment wall. Also, any gauging and sampling device in the compartment cover can be designed to provide a projection into the liquid surface to prevent VOC from escaping. The sampling device can also be equipped with a cover or lid that is closed at all times except when the device is in actual use. It is assumed that 95 percent of these emissions are recovered and used in the refinery fuel gas system.

12.3.7.3 Controlling Emissions from Process Unit Turnaround

A typical process unit turnaround would include pumping the liquid contents to storage, purging the vapors by depressurizing, flushing the remaining vapors with water, steam or nitrogen, and ventilating the vessel so workmen can enter. The major potential source of VOC emissions is in depressurizing the vapors to the atmosphere. After the vapors pass through a knockout pot to remove the condensable hydrocarbons, the vapors can be added to the fuel gas system, flared or directly vented to atmosphere. Atmospheric emissions will be greatly reduced if the vapors are combusted as fuel gas or flared until the pressure in the vessel is as close to atmospheric pressure as practicably possible. The exact pressure at which the vent to the atmosphere is opened will depend on the pressure drop of the disposal system. Most refineries should easily be able to depressurize processing units to five psig or below, before venting to the atmosphere. Many refineries depressurize a vessel to almost atmospheric pressure and then steam the vessel to the flare header, before opening it to atmosphere. In some refineries, the hydrocarbon concentration is as low as 1 percent to 30 percent before the vessel is vented to atmosphere. It is assumed that no VOC emissions are recovered and used in the refinery fuel gas system.

* * * *

The sections which follow discuss the costs of implementing these control techniques at the refinery in Tennessee.

12.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the three emission control systems described in Section 12.3 are described for vacuum producing systems, wastewater separators and process unit turnarounds individually, followed by an aggregation of these costs for the refinery in Tennessee.

12.4.1 Costs for Emission Control Systems

The installed capital costs for the three emission control systems (summarized in Exhibit 12-5, on the following page) were derived from analysis of the RACT guidelines, from interviews with refinery operators and major oil companies and from previous cost and economic studies of refineries.

Control measures for vacuum producing systems at a typical 100,000 barrel per day capacity refinery range in costs from approximately $24,000 for vacuum producing systems using either surface condensers or mechanical pumps to $52,000 for vacuum producing systems using contact (barometric) condensers. These cost estimates are based on the refinery requiring the following equipment.

- For vacuum producing systems using either surface condensers or mechanical pumps, typical equipment includes:
  - 200 feet of piping
  - 6 valves
  - 1 flame arrestor
- For vacuum producing systems using contact (barometric) condensers, typical equipment includes:
  - 400 feet of piping
  - 12 valves
  - 2 flame arrestors
  - Hotwell cover area of 100 square feet

Control of wastewater separators using covers can range from $30 per square foot to $2,000 per square foot, depending

Exhibit 12-5

U.S. Environmental Protection Agency
INSTALLED CAPITAL COSTS OF VAPOR CONTROL SYSTE FOR VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS

Vacuum Producing Systems		Wastewater Separators ($, 1977)	Process Unit Turnarounds ($, 1977)
Surface Condensers or Mechanical ($, 1977)	Contact Condensers ($, 1977)		
24,000[a]	52,000[b]	63,000[c]	100,000[d]

Note: Capital costs are for a typical 100,000 barrel per day refinery.

a. Equipment includes 200 feet of piping, 6 valves and 1 flame arrestor.

b. Equipment includes 400 feet of piping, 12 valves, 2 flame arrestors, 100 ft.^{2} area hotwell cover.

c. Cover for 5,000 ft.^{2} wastewater separator.

d. Equipment includes 1,000 ft. of piping and 20 valves.

Source: Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77025, pp. 4-10.

upon the types of covers used according to an interview with Exxon Corporation. The RACT guideline document entitled Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds used a cost of $12.60 per square foot which was also used in this report.

Equipment required for controlling emissions from process unit turnarounds basically includes piping and valves. The installed capital costs for a typical 100,000 barrel per day refinery would be in the range of $10,000 per process unit; there are, on the average, ten process units for a 100,000 barrel per day refinery.

Cost estimates obtained from Control of Refinery Vacuum Producing Systems, Wastewater Separators and Process Unit Turnarounds, EPA-450/2-77-025 and verified through interviews will vary from one refinery to another reflecting the variability in refinery size, configuration, age, product mix and degree of control.

In Tennessee, the one refinery has controlled the vacuum producing systems and the process units, but has not controlled the wastewater separation area.

The remainder of this section, therefore, presents the costs for covering the wastewater separator.

12.4.2 Costs to the Statewide Industry

Exhibit 12-6, on the following page, shows the aggregation of vapor recovery costs to the refinery in Tennessee. The cost estimates are based on the following:

- The wastewater separator is estimated to be 880 square feet.
- The refinery is equipped with vacuum producing systems with contact condensers.
- The refinery has 6 process units.
- Installed capital cost includes parts and labor.
- Annualized direct operating costs, expected to be 3 percent of installed capital costs, include costs for labor, utilities, recordkeeping and training.

Exhibit 12-6

U.S. Environmental Protection Agency

STATEWIDE COSTS FOR VAPOR CONTROL SYSTEMS FOR REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS

Characteristics/Cost Item	Data
Number of refineries	1
Total refinery capacity (barrels per day)	43,900
Emission reduction (tons/year)	609
Installed capital ($, 1977)	11,090
Direct annual operating cost ($, 1977)	330
Annual capital charges ($, 1977)	2,770
Annual gasoline credit[a] ($, 1977)	0
Net annualized cost ($, 1977)	3,100
Annualized cost per ton of emissions reduced ($ per ton)	5

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[a] Based on the assumption that emissions will be sent to a flare.

Source: Booz, Allen & Hamilton Inc.

- Annualized capital charges, estimated to be 25 percent of installed capital costs, include costs for depreciation, interest, maintenance, taxes and insurance.

- Based on an interview with the manufacturer it is estimated that no petroleum credit would be accrued as VOC emissions would be sent to a flare rather than being recovered.

- Net annualized costs are the sum of the capital charges and direct operating costs.

Actual costs to refinery operators may vary, depending on the type of manufacturer's equipment selected by the refinery operator.

Based on the above assumptions, the total capital cost to the industry for installing vapor recovery equipment is estimated to be $11,000. The annual cost is estimated to be $5 per ton.

12.5 DIRECT ECONOMIC IMPACTS

This section presents the direct economic impacts of implementing RACT for the refinery in Tennessee. The impacts include capital availability, technical feasibility and value of shipments. It was learned through interviews with the refinery operator that emissions from vacuum producing systems, and process unit turnarounds were controlled, but the wastewater separator was uncovered.

- Capital availability—The Tennessee refinery will need to raise an estimated $11,000 to implement RACT controls. It is expected that the refiner will be able to raise the sufficient capital nesessary for control.

- Technical feasibility—Emission controls for wastewater separators have been successfully demonstrated in several refineries in the United States. It is expected that Tennessee will be able to successfully implement emission controls to comply with RACT.

12.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

- Employment—No change in employment is anticipated from implementing RACT in Tennessee.
- Market structure—The market structure will remain unchanged when RACT is implemented in Tennessee.
- Productivity—Worker productivity will probably be unaffected by implementing RACT in Tennessee.

* * * *

Exhibit 12-7, on the following page, summarizes the findings of this chapter.

EXHIBIT 12-7

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR REFINERY VACUUM PRODUCING SYSTEMS, WASTEWATER SEPARATORS AND PROCESS UNIT TURNAROUNDS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	1
Indication of relative importance of industrial section to state economy	1977 industry sales were $181 million. The estimated annual crude oil throughput was 13 million barrels
Current industry technology trends	No controls have been implemented on wastewater separation area
1977 VOC actual emissions	873 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Vapor recovery of emissions by piping emissions to refinery fuel gas system or flare and covering wastewater separators
Estimated method of VOC control to meet RACT guidelines	Vapor recovery by piping emissions from vacuum producing systems to refinery fuel gas system, cover wastewater separator, pipe emissions from process units to flare

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	11,000
Annualized cost (statewide)	3,100
Price	No major impact
Energy	No major impact
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
VOC emission after control	264 tons per year
Cost effectiveness of control	$5 annualized cost/annual ton of VOC reduction

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Source: Booz, Allen & Hamilton Inc.

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- Mr. Fritz, Exxon Research, New Jersey
- Mr. Gordon Potter, Exxon Corporation, Houston, Texas
- Mr. Chuck Masser, U.S. EPA, Research Triangle Park, North Carolina
- Mr. Karlowitz, American Petroleum Institute, Washington, D.C.
- Delta Refining Company, Memphis, Tennessee

13.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR TANK TRUCK GASOLINE LOADING TERMINALS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT controls for tank truck gasoline loading terminals in the State of Tennessee. The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on the RACT guidelines, previous studies of tank truck gasoline loading terminals, interviews and analysis.

13.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for tank truck gasoline loading terminals in the State of Tennessee.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

13.1.1 Industry Statistics

Industry statistics on tank truck gasoline loading terminals were obtained from several sources. All data were converted to a base year, 1977, based on the following specific methodologies:

- The number of establishments for 1977 was estimated from data in the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals and from the decline in the number of establishments nationally from 1969 to 1972.

- The number of employees in 1977 was derived by determining the number of employees per establishment in 1972 from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals and multiplying this factor by the number of establishments estimated for 1977.

- The number of gallons sold from terminals in 1977 in Tennessee was estimated from total gasoline consumption in the state. Based on data in Kentucky it was found that approximately 90 percent of statewide consumption of gasoline was distributed through terminals. This finding was used in Tennessee.

- Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold from terminals in Tennessee in 1977 by the national dealer tankwagon price in

1977 (42.5¢/gallon), which was reported in the National Petroleum News Factbook, 1978.

13.1.2 VOC Emissions

VOC emissions for tank truck gasoline loading terminals in Tennessee were calculated by multiplying U.S. EPA emission factors by terminal throughput. U.S. EPA emission factors were reported in Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA-450/3-78-017. Emissions were based on all terminals either top submerged filling or bottom loading.

13.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions for tank truck gasoline loading terminals are described in Control of Hydrocarbons from Tank Trucks Gasoline Loading Terminals, EPA-450/2-77-026. These data provide the alternatives available for controlling VOC emissions from tank truck gasoline loading terminals. Several studies of VOC emission control were also analyzed in detail, and interviews with petroleum trade associations, terminal operators and vapor control equipment manufacturers were conducted to ascertain the most likely types of control processes which would be used in terminals in Tennessee. The specific studies analyzed were: Demonstration of Reduced Hydrocarbon Emissions from Gasoline Loading Terminals, PB-243 363; Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921; and The Economic Impact of Vapor Control in the Bulk Storage Industry, draft report to U.S. EPA by Arthur D. Little.

The alternative types of vapor control equipment likely to be applied to tank truck gasoline loading terminals were analyzed. Model plants reflecting each control alternative were defined and each type of control alternative used was applied to the number of tank truck gasoline loading terminals in the state. The methodology for the cost analysis of VOC emissions control is described in the following paragraphs.

13.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used

- Estimating the probable use of each type of control system

- Defining systems components

- Developing installed capital costs for systems components

- Aggregating installed capital costs for each alternative control system

- Defining two model terminals based on throughput levels

- Developing costs of the alternative control systems for the two model terminals including:

  - Installed capital cost
  - Direct operating costs
  - Annualized capital charges
  - Gasoline credit
  - Net annualized cost

- Assigning model terminal costs to terminals in Tennessee

- Aggregating costs to the total industry in Tennessee.

Costs were determined mainly from analyses of the RACT guidelines and from interviews with petroleum marketers' associations, terminal operators and vapor control equipment manufacturers.

The assignment of the estimated cost of control for terminals in Tennessee required a profile of tank truck gasoline loading terminals in the state by size of gasoline throughput. A national profile is presented which was used to approximate the terminals in Tennessee since no data specific to Tennessee were available.

13.1.5 Economic Impact

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment and productivity as a result of implementing RACT controls in Tennessee.

13.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, costs and economic impact of implementing RACT controls on gasoline terminals in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 13-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 13-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		●	
Emissions			●
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact			●
Overall quality of data			●

Source: Booz, Allen & Hamilton Inc.

13.2 INDUSTRY STATISTICS

Industry character, statistics and business trends for tank truck gasoline loading terminals in Tennessee are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the gasoline terminal industry to state economic indicators, a historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT on tank truck gasoline loading terminals in Tennessee.

13.2.1 Size of the Industry

There were an estimated 31 tank truck gasoline loading terminals, as of 1977, in Tennessee. Industry sales were in the range of $1.036 billion, with an estimated yearly throughput of 2.439 billion gallons of gasoline. The estimated number of employees in 1977 was 340. These data and the sources of information are summarized in Exhibit 13-2, on the following page. Annual capital investments have not been estimated. In general, tank truck gasoline loading terminal investments are for plant and equipment to replace worn-out facilities, modernize the establishments or improve operating efficiences.

13.2.2 Comparison of the Industry to the State Economy

A comparison of the tank truck gasoline loading terminal industry to the economy of the State of Tennessee is shown in this section by comparing industry statistics to state economic indicators. Employees in the tank truck gasoline loading terminal industry represent 0.06 percent of the total state civilian labor force of Tennessee. The value of gasoline sold from terminals represented approximately 7 percent of the total value of wholesale trade in Tennessee in 1977.

13.2.3 Characterization of the Industry

Tank truck gasoline loading terminals are the primary distribution point in the petroleum product marketing network as shown in Exhibit 13-3, following Exhibit 13-2. Terminals receive gasoline from refineries by pipeline, tanker or barge.

Exhibit 13-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR TANK TRUCK
GASOLINE LOADING TERMINALS IN TENNESSEE

Number of Establishments	Number of Employees	Sales ($ Billion, 1977)	Gasoline Sold (Billions of Gallons)
31	340[b]	1.036[c]	2.439[d]

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a. Projected from the 1969 and 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals.

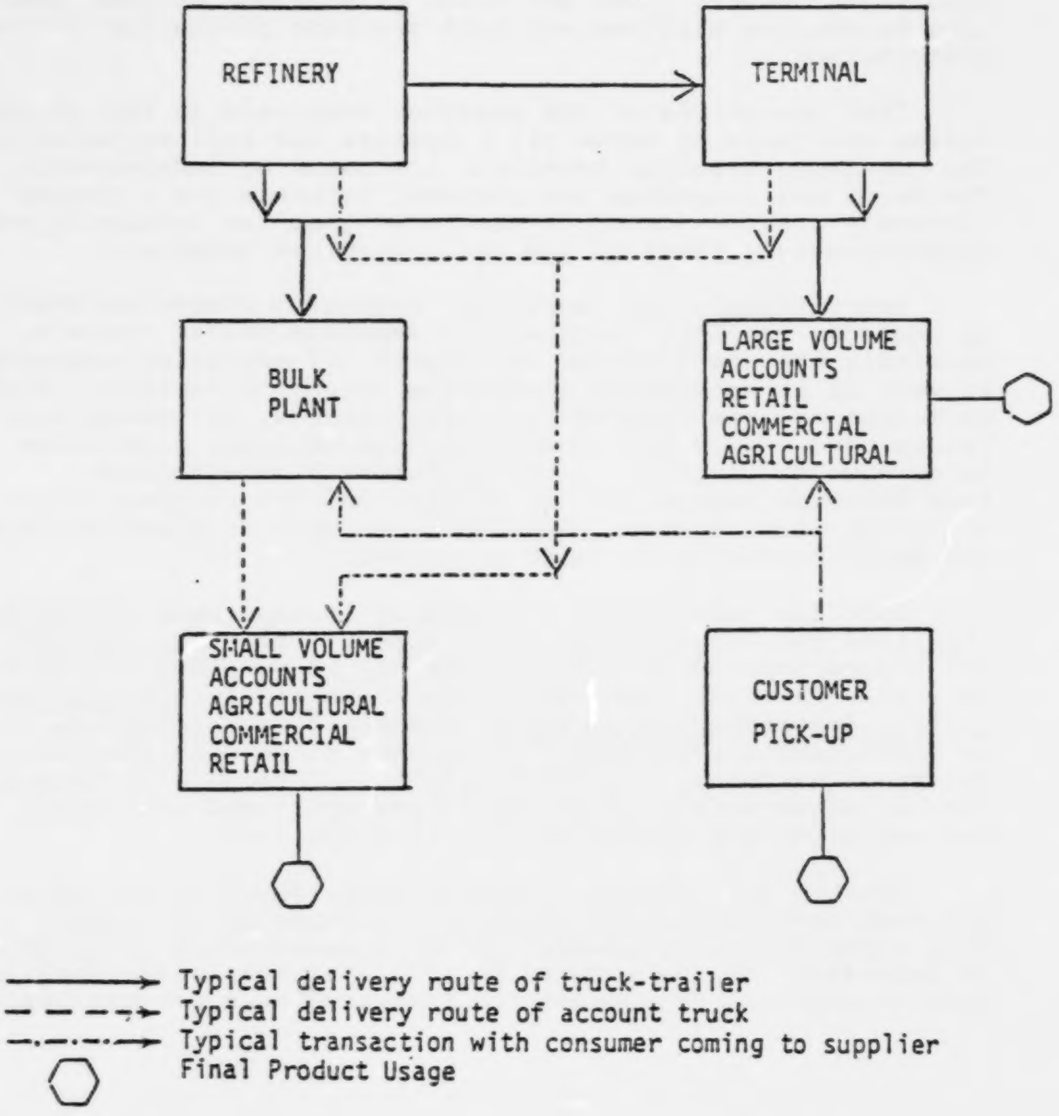
b. Booz, Allen & Hamilton Inc. estimate based on the ratio of the number of employees to the number of establishments in 1972.

c. Number of gallons of motor gasoline sold in 1977 multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon).

d. Booz, Allen & Hamilton, Inc. estimated based on 90 percent of total gasoline consumed statewide was distributed through terminals.

Exhibit 13-3

U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK


REFINERY
TERMINAL
BULK PLANT
LARGE VOLUME ACCOUNTS RETAIL COMMERCIAL AGRICULTURAL
SMALL VOLUME ACCOUNTS AGRICULTURAL COMMERCIAL RETAIL
CUSTOMER PICK-UP
Typical delivery route of truck-trailer
Typical delivery route of account truck
Typical transaction with consumer coming to supplier
Final Product Usage

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 240/1-77-013, September 1976, p. 3-2.

Most gasoline terminals load all of the petroleum product they receive into truck transports at the terminals' loading racks. These truck transports usually have storage capacities between 8,000 and 9,000 gallons and deliver gasoline to service stations and bulk gasoline plants for further distribution.

Over two-thirds of the gasoline terminals in the United States are owned by major oil companies and refiner/marketers. The remaining gasoline terminals are owned by independents. The major oil companies and regional refiners own a proportionately greater number of the large gasoline terminals and proportionately fewer of the small gasoline terminals.

Approximately ten years ago, petroleum companies began to consider gasoline terminals as separate profit centers. Terminals are now expected to recover all operating expenses as well as to provide an acceptable return on capital. Since terminals are now treated as profit centers, petroleum marketers have closed many uneconomic and marginal facilities throughout the country. Some marketers have withdrawn from selected regions of the country as part of their overall corporate strategy. Gasoline terminals in these markets are being consolidated, sold or closed.

Gasoline terminals are generally located near refineries, pipelines and large metropolitan areas. The daily throughput ranges from 20,000 gallons per day to over 600,000 gallons per day. Terminal characteristics presented in Hydrocarbon Control Strategies for Gasoline Marketing Operations are used to characterize terminals in Tennessee since data specific to Tennessee terminals are not available. Terminals in Tennessee can be characterized as having 60 percent fixed roof tanks and employing top submerged or bottom filling.

Exhibit 3-4, on the following page, shows an estimated national distribution of gasoline terminals by throughput. This distribution is assumed to be representative of terminals in Tennessee for the purpose of this analysis, since detailed data on terminal throughput for Tennessee were not available.

Exhibit 13-4

U.S. Environmental Protection Agency
DISTRIBUTION OF TANK TRUCK GASOLINE LOADING TERMINALS BY AMOUNT OF THROUGHPUT IN THE UNITED STATES

Gasoline Throughput (gallons per day)	Percentage of Plants
Less than 200,000	48
200,000 to 399,000	27
400,000 to 599,000	21
Over 600,000	4
TOTAL	100

Source: Bureau of Census, 1972 Census of Wholesale Trade

13.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on tank truck gasoline loading terminal operations, estimated VOC emissions from terminal operations in Tennessee, the extent of current controls in use, the requirements of vapor control required by RACT and the likely RACT alternatives which may be used for controlling VOC emissions from gasoline terminals in Tennessee.

13.3.1 Tank Truck Gasoline Loading Terminal Operations

Tank truck gasoline loading terminals are the primary distribution facilities which receive gasoline from pipelines, tankers and barges; store it in above-ground storage tanks; and subsequently dispense it via tank trucks to bulk gasoline plants and service stations. Tank truck gasoline loading terminals with an average daily gasoline throughput of 20,000 gallons per day or more (as defined by EPA) require vapor control equipment to reduce VOC emissions from gasoline terminal operations. Terminal facilities and operations are described in detail in Hydrocarbon Control Strategies for Gasoline Marketing Operations.

13.3.2 Emission and Current Controls

This section presents the estimated VOC emissions from tank truck gasoline loading terminals in Tennessee in 1977 and the current level of emission control already implemented in the state. Exhibit 13-5, on the following page, shows the total estimated emissions in tons per year from gasoline terminals in Tennessee. The estimated VOC emissions from the 31 tank truck gasoline loading terminals are 8,697 tons per year. No terminal in Tennessee has been identified as having vapor recovery equipment installed.

13.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from tank truck gasoline loading terminals require the following control systems:

- Top submerged or bottom fill of gasoline storage tanks and outgoing tank trucks

- Vapor collection from trailer-transport truck loading

Exhibit 13-5

U.S. Environmental Protection Agency
VOC EMISSIONS FROM TANK TRUCK GASOLINE LOADING TERMINALS IN TENNESSEE

Number of Facilities	Estimated Annual Throughput (Billions of gallons)	Total Emissions (Tons/year)
31	2.439	8,697

Source: Booz, Allen & Hamilton Inc.

- Vapor recovery or thermal oxidation of collected vapors

- Proper operation and maintenance of equipment.

Exhibit 13-6, on the following page, summarizes the RACT guidelines for VOC emissions control from tank truck gasoline loading terminals.

In Tennessee, VOC emission sources less than 100 tons per year and not located in urban non-attainment areas are exempted from state VOC emission regulations. It was assumed that no terminal in the state would be exempted since terminals generally generate VOC emmissions greater than 100 tons per year.

13.3.4 Selection of the Most Likely RACT Alternatives

Control of VOC emissions from tank truck gasoline loading terminals is achieved using submerged or bottom filling of storage tanks and of tank trucks and vapor control of the loading of outgoing trailer-transport trucks. There are several alternative means of achieving vapor control at tank truck gasoline loading terminals, based on the type of vapor control equipment installed.

Four likely alternatives for vapor control are:

- Adsorption/absorption
- Compression refrigeration absorption
- Refrigeration
- Thermal oxidation.

Each type of vapor control system is briefly described below.

13.3.4.1 Adsorption/Absorption (AA)

Vapor control by adsorption/absorption is achieved by the following method. Vapors from tank truck loading operations are collected and directed to one of two activated carbon beds. Vapors are condensed into pores in the carbon. These vapors are then regenerated by pulling a vacuum over the bed. Cold gasoline is then circulated in a separator and the hot vapors are absorbed into the cold gasoline. This process has recently been marketed and is becoming competitive with the refrigeration system described below. It has been reported that less maintenance is required for this type of vapor recovery system than for the other three types.

Exhibit 13-6

U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR TANK TRUCK GASOLINE LOADING TERMINALS

Facilities Affected	Sources of Emissions	RACT Control Guidelines
Tank truck terminals with daily throughput of greater than 76,000 liters (20,000 gallons) of gasoline	Filling tank trucks and breathing and working losses from storage tanks	Top submerge or bottom fill tank truck and one of the following vapor control systems: - Adsorption/ Absorption - Refrigeration - Compression Refrigeration Absorption - Thermal Oxidation
	Leakage	Maintenance of areas that may leak

Source: U.S. Environmental Protection Agency

13.3.4.2 Compression Refrigeration Absorption (CRA)

Vapor control by compression refrigeration absorption is achieved by the following method. Vapors from tank truck loading operations are collected in a vapor holder. The pressure is increased in the holder, thus causing vapors to condense. Further condensation is then achieved by mixing chilled gasoline and vapors under pressure and the vapors are absorbed into the gasoline. This system is becoming less popular than the more recently developed refrigeration system described below and it is not expected that this type of system will be used in Tennessee.

13.3.4.3 Refrigeration (RF)

Vapor recovery using refrigeration is based on the condensation of gasoline vapors by refrigeration at atmospheric pressure. Vapors displaced from tank truck loading operations enter a horizontal fin-tube condenser where they are cooled to a temperature of about -40°F and condensed. Because vapors are treated as they are vented from tank trucks, no vapor holder is required. Condensate is withdrawn from the condenser and the remaining air containing only a small amount of hydrocarbons is vented to the atmosphere. This system is priced competitively with AA systems because of market pressure, although it is estimated to be more costly to build.

13.3.4.4 Thermal Oxidation (OX)

Vapor control by thermal oxidation is achieved by incineration devices. Gasoline vapors are displaced to a vapor holder. When the vapor holder reaches its capacity, vapors are released to the oxidizer, after mixing with a properly metered air stream, and combusted. Later models of this type of thermal oxidizer do not require vapor holders; vapors from the tank trucks during loading operations are vented directly to the thermal oxidizer. It is not expected that this type of vapor control system will be used in Tennessee since there are fire hazards with a flame and terminal operators are also reportedly reluctant to burn valuable hydrocarbons.

13.3.5 Leak Prevention from Tank Trucks

For vapor control systems to operate optimally, it is essential to maintain leakless tank trucks. This is achieved by using proper operating procedures and periodic maintenance of hatches, P-V valves and liquid and gaseous connections.

13.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs for VOC emission control equipment are presented in this section. The costs for the four types of vapor control systems described in Section 13.3 are presented for two model tank truck gasoline loading terminals. The final section presents a projection of model terminal control costs to the statewide industry.

13.4.1 Factory Costs for Four Types of Vapor Control Systems

The factory costs for the four types of vapor control systems (summarized in Exhibit 13-7, on the following page) were derived from analysis of the RACT guidelines; from interviews with terminal operators, major oil companies and equipment manufacturers; and from previous cost and economic studies of tank truck gasoline loading terminals.

Adsorption/absorption and refrigeration systems are expected to be the only two types of vapor control systems used at tank truck gasoline loading terminals in Tennessee. It is estimated that 50 percent of the systems will be adsorption/absorption and the other 50 percent will be refrigeration systems. Factory costs for both systems are assumed to be equal because of competitive pressures. Maintenance costs for refrigeration systems are approximately 2 percent higher than those for adsorption/absorption systems.

13.4.2 Costs for Two Model Tank Truck Gasoline Loading Terminals

Two model tank truck gasoline loading terminals and their associated control costs are characterized in this section. The costs are based on the control estimates for adsorption/absorption and refrigeration systems reported by equipment manufacturers and through interviews.

Exhibit 13-8, following Exhibit 13-7, defines two model tank truck gasoline loading terminal characteristics and associated control costs. It is assumed that approximately 50 percent of the terminals in Tennessee can be characterized by Model Terminal A; the remaining 50 percent are assumed to be characterized by Model Terminal B.

Exhibit 13-7

U.S. Environmental Protection Agency
FACTORY COSTS OF ALTERNATIVE VAPOR CONTROL SYSTEMS

Type of Control System	Factory Cost[a] for 250,000 gallon per day system ($000, 1977)	Factory Cost for 500,000 gallon per day system ($000, 1977)
Adsorption/Absorption	120[b]	155
Compression-Refrigeration-Absorption	128	164
Refrigeration	120[c]	155
Thermal Oxidation	72	95

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a. Costs are based on average of range of costs quoted by vendors to the U.S. Environmental Protection Agency and reported in The Economic Impact of Vapor Control on the Bulk Storage Industry, p. D.3.

b. Hydrotech Engineering reported a factory price of $92,000 for a 250,000 gallon per day unit.

c. Expect system priced competitively to adsorption/absorption system due to market pressures.

Source: Hydrotech, U.S. Environmental Protection Agency, Exxon and Booz, Allen & Hamilton Inc. estimates.

Exhibit 13-8

U.S. Environmental Protection Agency

DESCRIPTION AND COST OF MODEL TANK TRUCK GASOLINE LOADING TERMINALS EQUIPPED WITH VAPOR CONTROL SYSTEMS

Tank Truck Gasoline Loading Terminal Characteristics	Model Terminal A	Model Terminal B
Throughput	250,000 gallons/day	500,000 gallons/day
Loading racks	1	1
Storage tanks	3	3
Tank trucks	6	15
Compartments per account truck	4	4
Vapor control systems	Adsorption/absorption Refrigeration	Adsorption/Absorption Refrigeration

Tank Truck Gasoline Loading Terminal Costs	AA	RF	AA	RF
Installed capital cost	$258,000	$258,000	$355,000	$355,000
Annual direct operating costs				
. Electricity	3,900	9,900	7,800	19,800
. Maintenance	10,800	13,200	13,950	17,050
. Operating Labor	1,500	1,500	1,500	1,500
. Carbon replacement	2,400	-	4,700	-
Subtotal (direct operating costs)	18,600	24,600	27,950	38,350
Annualized capital charges	54,180	54,180	74,440	74,550
Net annualized cost (not including gasoline credit)	72,780	78,780	102,500	112,900

The costs for the model terminals are used in Section 13.4.3 to project costs of vapor control equipment to the industry statewide. The costs for each model terminal are:

- Installed capital cost, which includes equipment and modification costs, labor and costs to modify trucks ($3,000 per truck)
- Annual direct operating costs which include electricity, maintenance, operating labor and carbon replacement costs. Maintenance costs for the adsorption/absorption system are slightly lower than those for refrigeration
- Annualized capital charges include costs for depreciation, interest, taxes and insurance and are estimated to be 21 percent of the installed capital cost
- Net annualized operating costs, which are the sum of the capital charges and direct operating costs. It should be noted that gasoline credit has not yet been accounted for. Gasoline credit will be taken into account when the costs are projected to the industry.

Another cost characterization that can be made is hydrocarbon reduction versus cost. This finding will also be shown in the statewide analysis.

13.4.3 Projection to the Statewide Industry

Exhibit 13-9, on the following page, shows the projected vapor recovery costs to the statewide industry in Tennessee. The estimates are based on the following assumptions:

- In Tennessee, 50 percent of the tank truck gasoline loading terminals can be characterized by Model Terminal A and the remaining can be characterized by Model Terminal B
- Fifty percent of the terminals will implement the adsorption/absorption vapor control system to comply with RACT and the other 50 percent will implement the refrigeration system to comply with RACT

Exhibit 13-9

U.S. Environmental Protection Agency
COSTS OF VAPOR CONTROL SYSTEMS FOR TANK TRUCK GASOLINE LOADING TERMINALS IN TENNESSEE

Characteristics/Cost Item	Data
Number of terminals	31
Total annual throughput (billions of gallons)	2.439
Uncontrolled emissions (tons/year)	8,697
Emission reduction from terminals (tons/year)	7,827
Installed capital cost ($ million, 1977)	9.453
Direct annual operating cost ($ million, 1977)	0.842
Annualized capital charges ($ million, 1977)	1.985
Annual gasoline credit[a] ($ million, 1977)	1.275
Net annualized cost ($ million, 1977)	1.552
Annualized cost per ton of emissions, terminal emissions only ($ per ton)	233
Annualized cost per ton of emissions reduced[a] ($ per ton)	155
Annualized cost per ton of emissions reduced from gasoline marketing[b] ($ per ton)	188

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a. Based on 9,976 tons of emissions recovered which includes 90 percent of the 2,388 tons collected from gasoline service stations, a negligible amount collected from bulk plants and 7,827 tons collected at the terminal. Gasoline credit is calculated by multiplying the number of tons of emissions collected by the estimated number of gallons in a ton (294 gallons) by a price of $.39 per gallon.

b. Annualized cost of emissions reduced from gasoline marketing based on sum of net annualized costs from terminals, bulk plants, fixed roof tanks, and gasoline dispensing facilities divided by the sum of emissions reductions from these same categories.

Source: Booz, Allen & Hamilton Inc.

- RACT is implemented at bulk gasoline plants and gasoline service stations in the affected counties in the state. Ninety percent of the gasoline vapors collected from bulk gasoline plants and gasoline service stations are recovered and credited to the tank truck gasoline loading terminal.

Based on the above, the total cost to the industry for installing vapor recovery equipment is estimated to be $9.453 million. The amount of gasoline recovered from terminals, bulk gasoline plants and gasoline service stations is valued at $1.275 million. The annualized cost per ton of emissions controlled at terminals (including gasoline vapors that eventually would be recovered from service stations) is estimated to be $155 per ton. The overall cost per ton of emissions controlled from gasoline marketing in the state is estimated to be $188 per ton.

13.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls to the statewide industry, including availability of equipment and capital; feasibility of the control technology; and impact on state economic indicators.

13.5.1 RACT Timing

RACT is assumed to be implemented by January 1, 1982. This implies that tank truck gasoline loading terminal operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on terminal operators including:

- Determining appropriate vapor control system
- Raising capital to purchase equipment
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

13.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Several tank truck gasoline loading terminal operators in the United States have successfully implemented vapor control systems. State adoption of RACT regulations will generate a new demand for vapor control systems. It is expected that sufficient leadtime is available to meet the increased demand of vapor recovery equipment.

In the area of economic feasibility it has been reported from interviews that terminal operators should have access to capital to purchase vapor control equipment, and it is expected from information through interviews that terminals will not cease operations because of the cost of implementing RACT.

EXHIBIT 13-10

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF
IMPLEMENTING RACT FOR TANK TRUCK GASOLINE
LOADING TERMINALS IN TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	31
Indication of relative importance of industrial section to state economy	1977 industry sales were $1.036 billion. The estimated annual throughput was 2.44 billion gallons
Current industry technology trends	New terminals are currently being designed with vapor recovery equipment
1977 VOC actual emissions	3,775 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Submerge or bottom fill and vapor recovery

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$9.453 million
Annualized cost (statewide)	$1.552 million (approximately 0.15 percent of value of shipments)
Price	Assuming a direct cost passthrough $0.0006 per gallon
Energy	Assuming full recovery of gasoline—net savings of 53,500 barrels annually from terminal emissions
Productivity	No major impact
Employment	No direct impact
Market structure	No direct impact
Problem area	Gasoline credit from vapors from bulk gasoline plants and gasoline service stations require uniform RACT requirements through the state
VOC emission after control	870 tons per year
Cost effectiveness of control	$155 annualized cost/annual ton of VOC reduction from terminals including gasoline credit from vapors returned from bulk gasoline plants and gasoline service stations

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Source: Booz, Allen & Hamilton Inc.

13.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary economic impact of implementing RACT on employment, market structure and productivity.

- Employment—No decline in employment is predicted since terminals should not close solely because of RACT requirements. A slight increase in operating and maintenance labor will be required through implementation of RACT but this is predicted to have minimal impact on any employment increase.
- Market structure—No change in market structure is expected to result from implementation of RACT.

* * * *

Exhibit 13-10, on the following page, presents a summary of the findings of this chapter.

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14.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR BULK GASOLINE PLANTS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT controls for bulk gasoline plants in three urban non-attainment counties in the State of Tennessee.[1] The chapter is divided into six sections including:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and VOC reduction benefit evaluations for the most likely RACT alternatives
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on the RACT guidelines, previous studies of bulk gasoline plants, interviews, and analysis.

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[1] The three urban non-attainment counties are: Davidson, Hamilton and Shelby. The regulation applies statewide for VOC emissions greater than 100 tons per year, with the exception of VOC emission sources located in urban non-attainment areas. Since bulk plants in general have emissions less than 100 tons per year, only non-attainment counties are considered in this analysis. Bulk plants with tank capacity less than 2000 gallons or with throughput less than 4000 gallons per day are also exempt from regulation.

14.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for bulk gasoline plants in affected counties in the State of Tennessee.

An overall assessment of the quality of the estimates is detailed in the latter part of this section.

14.1.1 Industry Statistics

Industry statistics on affected bulk gasoline plants were obtained from several sources. All data were converted to a base year, 1977, based on specific methodologies:

- The number of affected bulk plants in the urban non-attainment counties was obtained from the Tennessee State Implementation Plans and through interviews with state officials.

- The number of employees in 1977 was derived from the 1972 Census of Wholesale Trade, Petroleum Bulk Stations and Terminals by determining the number of employees per establishment in 1972 and multiplying this factor by the number of affected establishments reported for 1977.

- The number of gallons of gasoline sold from affected bulk plants was estimated by Booz, Allen & Hamilton based on emission data in the Tennessee State Implementation Plans.

- Sales, in dollars, of motor gasoline for 1977 were estimated by multiplying the number of gallons of gasoline sold in 1977 from affected bulk gasoline plants by the national dealer tankwagon price in 1977 (42.51¢/gallon--reported in the National Petroleum News Factbook, 1978).

14.1.2 VOC Emissions

Emissions from the affected bulk gasoline plants were obtained from the Tennessee State Implementation Plans.

14.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from bulk gasoline plants are described in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035. These data provide the alternatives available for controlling VOC emissions from bulk gasoline plants. Several studies of VOC emission control were also analyzed in detail, and interviews with petroleum trade associations, bulk plant operators, and vapor control equipment manufacturers were conducted to ascertain the most likely types of control processes which would be used at bulk gasoline plants in Tennessee. The specific studies analyzed were Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014; Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013; Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, EPA PB-236 921; and Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA PB-267-096.

14.1.4 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the alternative types of control systems likely to be used
- Estimating the probable use of each type of control system
- Defining systems components
- Developing installed capital costs for systems components
- Aggregating installed capital costs for each alternative control system
- Defining a model plant
- Developing costs of control systems for the model plant including

  - Installed capital cost
  - Direct operating costs
  - Annualized capital charges
  - Gasoline credit
  - Net annualized cost

- Assigning model plant costs to affected bulk plants in Tennessee

- Aggregating costs to the affected industry in Tennessee.

Costs were determined from analyses of the following previous studies:

- Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035

- Study of Gasoline Vapor Emission Controls at Small Bulk Plants, EPA PB-267 096

- Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013

- Evaluation of Top Loading Vapor Balance Systems for Small Bulk Plants, EPA 340/1-77-014

and from interviews with petroleum marketers' associations, bulk plant operators, and vapor control equipment manufacturers.

Bulk plants' characteristics for the affected bulk gasoline plants in Tennessee were determined from data in the Tennessee State Implementation Plans.

14.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital availability and equipment availability; comparing the direct costs of RACT control to various state economic indicators; and assessing the secondary effects on market structure, employment, and productivity as a result of implementing RACT controls in Tennessee.

14.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost, and economic impact of implementing RACT controls at bulk gasoline plants in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies, and best engineering judgment. Exhibit 14-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 14-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		●	
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions			●
Economic impact		●	
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

14.2 INDUSTRY STATISTICS

Industry characteristics, statistics, and business trends for affected bulk gasoline plants in Tennessee are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the affected bulk gasoline plant industry to state economic indicators, a historical characterization and description of the industry, and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on the affected industry from implementing RACT in the urban non-attainment counties in Tennessee.

14.2.1 Size of the Industry

There are two affected bulk gasoline plants in the urban non-attainment counties in Tennessee. Industry sales from affected bulk plants are estimated to be in the range of $1.36 million, with an estimated yearly throughput of 3.2 million gallons of gasoline. The estimated number of employees is 10. These data and the sources of information are summarized in Exhibit 14-2, on the following page. Annual capital investments have not been estimated. In general, bulk plant capital investments are for plant and equipment to replace worn-out facilities, modernize the establishments or improve operating efficiencies.

14.2.2 Comparison of the Industry to the State Economy

A comparison of the affected bulk gasoline plant industry to the economy of the State of Tennessee is shown in this section by comparing industry statistics to state economic indicators. Employees in the bulk gasoline plant industry represent an insignificant percent of the total state civilian labor force of Tennessee. The value of gasoline sold from the affected bulk plants represents approximately 0.01 percent of the total value of wholesale trade in Tennessee.

14.2.3 Characterization of the Industry

Bulk plants are an intermediate distribution point in the petroleum product marketing network as shown in Exhibit 14-3, following Exhibit 14-2. Bulk gasoline plants compete with bulk gasoline tank terminals and large retail

Exhibit 14-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR AFFECTED
BULK GASOLINE PLANTS IN TENNESSEE

Number of Establishments	Number of Employees	Sales ($ Million, 1977)	Gasoline Sold (Millions of Gallons)
2[a]	10[b]	1.36[c]	3.2[d]

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a. Tennessee State Implementation Plans and interviews with state officials.

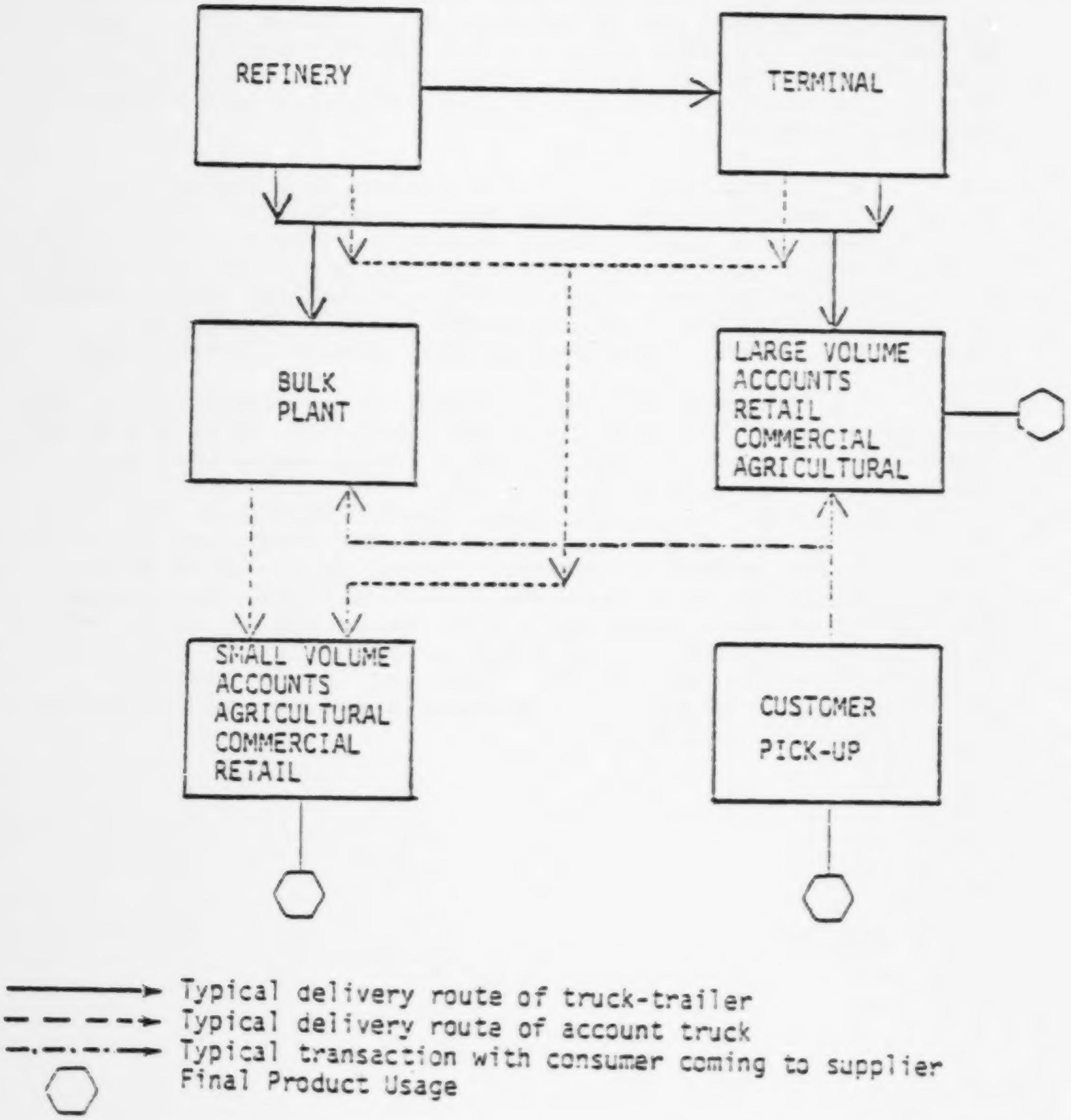
b. Booz, Allen & Hamilton estimate based on the ratio of the number of employees to the number of establishments in 1972.

c. Number of gallons of motor gasoline sold multiplied by the national dealer tankwagon price in 1977 (42.51¢/gallon), National Petroleum News Factbook, 1978.

d. Estimated from emissions data presented in the Tennessee State Implementation Plans.

Source: Booz, Allen & Hamilton Inc.

Exhibit 14-3
U.S. Environmental Protection Agency
GASOLINE DISTRIBUTION NETWORK


REFINERY
TERMINAL
BULK PLANT
LARGE VOLUME ACCOUNTS RETAIL COMMERCIAL AGRICULTURAL
SMALL VOLUME ACCOUNTS AGRICULTURAL COMMERCIAL RETAIL
CUSTOMER PICK-UP
Typical delivery route of truck-trailer
Typical delivery route of account truck
Typical transaction with consumer coming to supplier
Final Product Usage

Source: Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976, p. 3-2.

Reproduced from best available copy.

gasoline outlets. Ownership and operation of bulk plants are predominantly by independent jobbers and commissioned agents but also include cooperatives and salaried employees. The independent jobber owns the equipment and structures at his bulk plant, the inventory, and rolling stock, and he contracts directly with the oil company for gasoline. A commissioned agent usually does not own the equipment and facilities but operates the bulk plant for a major integrated oil company.

Bulk gasoline plants are typically located near towns and small cities, since their predominant market is agricultural and small retail accounts. The maximum daily throughput of a bulk gasoline plant ranges from less than 2,000 gallons per day up to 20,000 gallons per day. Exhibit 14-4, on the following page, shows the estimated plant throughput for the two affected bulk plants in Tennessee.

It is estimated that nationally the majority of the bulk gasoline plants are up to 25 years old, with a few new modernized, higher volume plants. Forty years ago, bulk gasoline plants were a major link in the gasoline distribution network. From that time, their importance has been declining in the marketing sector of the petroleum industry, basically for economic reasons. There is evidence that profitability in bulk gasoline plants has been decreasing. The number of bulk gasoline plants decreased by 11 percent nationally from 1967 to 1972 and is predicted to continue declining in the near term[1]. This decline is largely attributable to major oil companies disposing of commission-agent-operated bulk plants.

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[1] National Petroleum News Factbook, 1976.

Exhibit 14-4

U.S. Environmental Protection Agency
BULK GASOLINE PLANT THROUGHPUT FOR AFFECTED BULK PLANTS IN TENNESSEE

Bulk Plant	Annual Gasoline Throughput
A	1,360,000
B	1,840,000

Source: Booz, Allen & Hamilton Inc.

14.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on bulk gasoline plant operation, estimated VOC emissions from affected bulk gasoline plant operations in Tennessee, the extent of current control is use, the requirements of vapor control required by RACT and the likely RACT alternatives which may be used for controlling VOC emissions from affected bulk gasoline plants in Tennessee.

14.3.1 Bulk Gasoline Plant Operations

Bulk gasoline plants are typically secondary distribution facilities which receive gasoline from bulk gasoline tank terminals by trailer-transport trucks; store it in above-ground storage tanks; and subsequently dispense it via account trucks to local farms, businesses and service stations. Bulk gasoline plants with an average daily gasoline throughput of 20,000 gallons per day or less have been defined by EPA as requiring vapor control equipment to reduce VOC emissions from bulk gasoline plant operations.

Bulk gasoline plant facilities and operations are described in Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035.

14.3.2 Emissions and Current Controls

This section presents the estimated VOC emissions from the two affected bulk gasoline plants in Tennessee. It is assumed that both bulk plants employ splash filling and are not equipped with vapor control equipment. Exhibit 14-5 on the following page, shows the total estimated emissions in tons per year from the affected bulk gasoline plants in Tennessee. The estimated VOC actual emissions from the two bulk plants are 40 tons per year.

14.3.3 RACT Guidelines

The RACT guidelines for VOC emission control from bulk gasoline plants require the following control systems:

- Top submerged or bottom fill of gasoline storage tanks and outgoing account trucks
- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank

Exhibit 14-5
U.S. Environmental Protection Agency
VOC EMISSIONS FROM AFFECTED BULK
GASOLINE PLANTS IN TENNESSEE

Number of Facilities	Estimated Annual Throughput	Total Emissions
2	3.2	40

Source: Booz, Allen & Hamilton Inc.

- Vapor balancing between the gasoline storage tank and the outgoing account truck

- Proper operation and maintenance of equipment.

Exhibit 14-6, on the following page, summarizes the RACT guidelines for VOC emissions control from bulk gasoline plants.

14.3.4 Selection of the Most Likely RACT Alternatives

Control of VOC emission from bulk gasoline plants is achieved using submerged or bottom filling of storage tanks and account trucks and vapor balancing between the loading and unloading of incoming and outgoing trailer-transport trucks and the gasoline storage tanks. There are several alternative means of achieving vapor control at bulk gasoline plants, based on the manner in which the bulk plant is operated.

Three likely control alternatives, summarized in Exhibit 14-7, following Exhibit 14-6, are discussed separately in the paragraphs which follow.

14.3.4.1 Alternative I

Control Alternative I involves top submerged loading and equipping the bulk plant with a vapor balancing system. In detail, this control alternative implies:

- Submerged filling of gasoline storage tanks

- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank

- Submerged top loading of outgoing account trucks

- Vapor balancing of gasoline storage tank and outgoing account truck

- Equipping account trucks with vapor balancing connections.

It is estimated that both affected bulk plants in Tennessee would select Control Alternative I to achieve vapor recovery to meet the state RACT requirements. During interviews, the industry has questioned whether vapor

Exhibit 14-6

U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR BULK GASOLINE PLANTS

Facilities Affected	Sources of Emissions	RACT Control Guidelines
Bulk plants with daily throughputs of 76,000 liters (20,000 gallons) of gasoline or less	Vapor displacement from filling account trucks, and breathing losses and working losses from storage tanks	Submerge filling and vapor balancing: . Vapor balancing of transport truck and storage tank . Vapor balancing of storage and account truck
	Cracks in seals and connections	Proper operation maintenance
	Improper hook up of liquid lines and top loading nozzles	Proper operation maintenance
	Truck cleaning	Proper operation maintenance
	Pressure vacuum relief valves	Proper operation maintenance

Source: Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

Exhibit 14-7

U.S. Environmental Protection Agency
ALTERNATIVE CONTROL METHODS FOR VAPOR CONTROL AT BULK GASOLINE PLANTS

Alternative Number	Description of Control Method
I	Top submerged filling and vapor balance entire system
II	Vapor balance existing bottom filled bulk plant
III	Convert top filled bulk plant to bottom filled, and vapor balance total system.

Source: Booz, Allen & Hamilton Inc. analysis of Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA-450/2-77-035.

recovery by this control method will achieve 90 percent emissions recovery as stated in the RACT guidelines.

14.3.4.2 Alternative II

Control Alternative II involves implementing a complete vapor balancing system on bulk plants which currently operate with bottom filling. In detail this control alternative encompasses:

- Vapor balancing between the incoming trailer-transport truck and the gasoline storage tank
- Vapor balancing between the gasoline storage tank and the outgoing account truck
- Modification of account trucks to accommodate a vapor recovery connection.

It is estimated that none of the affected bulk gasoline plants currently use bottom filling.

14.3.4.3 Alternative III

Control Alternative III involves converting top loading bulk gasoline plants to bottom filling and implementing a complete vapor balancing system. In detail, this control alternative entails:

- Converting the loading rack to bottom filling
- Converting storage tank loading to bottom filling
- Vapor balancing the incoming trailer-transport truck and the gasoline storage tank
- Converting the account truck to bottom loading and installing vapor balancing connections on the account truck.

The additional cost of converting a bulk plant from top filling to bottom filling makes Control Alternative III more costly than Control Alternative I. This additional cost may be attributable to improved bulk plant operations, rather than compliance with the proposed limitations.

14.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR THE MOST LIKELY RACT ALTERNATIVES

Costs in 1977 dollars for VOC emission control equipment are presented in this section. The costs for the three alternative control systems described in Section 14.3 are described individually, followed by costs for a typical bulk plant. The final section then presents a projection of typical bulk gasoline plant control costs to the affected industry.

14.4.1 Costs for Alternative Control Systems

The costs for the three alternative control systems (summarized in Exhibit 14-8, on the following page) were derived from analysis of the RACT guidelines, from interviews with bulk plant operators and petroleum marketing trade associations and from previous cost and economic studies of small bulk plants.

Control Alternative I is expected to be the system used for affected bulk plants in Tennessee. The U.S. EPA currently endorses the cost estimates developed by Pacific Environmental Services, Inc. for the Houston/Galveston area bulk plants. However, several large volume bulk plant operators who were interviewed have reported vapor control costs in excess of $50,000 which included conversion of the loading rack to bottom filling.

Control Alternative II is similar in cost to Control Alternative I.

Control Alternative III is the most costly control system. Several bulk gasoline plant operators interviewed in California and Maryland have adopted this system, although it cannot be shown from the data in Tennessee that any bulk gasoline plant operator would be willing to implement a system this costly. This alternative, therefore, is not included in the projection of vapor control costs to the affected industry in the next section.

14.4.2 Costs for Model Bulk Plant

A model bulk plant and its associated vapor control costs are characterized in this section. The costs are based on the control estimates for Control Alternative I, reported by Pacific Environmental Services, Inc. for bulk

Exhibit 14-8

U.S. Environmental Protection Agency

COSTS OF ALTERNATIVE VAPOR CONTROL SYSTEMS

Cost Estimates	Alternative I	Alternative II	Alternative III (Includes conversion to bottom filling)
National Oil Jobbers Council estimate	1 truck (4 compartments) 1 loading rack (3 arms) 3-inch Pre-set meters Direct cost (no labor) $20,524 (without air) $22,754 (with air)	Similar to costs for alternative I	1 truck (4 compartments) 1 loading rack (3 arms) 3-inch system Pre-set meters Direct cost (no labor) $27,729
Pacific Environmental Services estimate of Houston/Galveston area system	1 loading rack Meters Average installed cost $3,200 (without metering) $7,700 (with metering)		
Wiggins System			1 truck (4 compartments) 1 loading rack (4 arms) Pre-set meters Installed cost $17,352 $18,416

Source: Booz, Allen & Hamilton Inc.

plants in the Houston/Galveston area. Several other bulk plant operators have reported costs in excess of $50,000 for vapor control systems although U.S. EPA estimates that these systems exceed the level of adequacy required to meet RACT.

Exhibit 14-9, on the following page, defines a model bulk plant's characteristics and associated control costs. It is assumed that the two affected bulk gasoline plants in Tennessee can be characterized by the model plant.

The costs for the model plant are used in Section 14.4.3 to project costs of vapor control equipment to the affected industry. The costs for the model plant are:

- Installed capital cost, which includes parts and labor
- Annual direct operating costs, expected to be 3 percent of installed capital costs, including costs for labor, utilities, recordkeeping and training costs
- Annualized capital charges, estimated to be 25 percent of installed capital costs, including costs for depreciation, interest, maintenance, taxes, and insurance
- Net annualized operating costs, which are the sum of the capital charges and direct operating costs. It should be noted that gasoline credit has not yet been accounted for. Gasoline credit will be taken into account when the costs are projected to the affected industry.

Another cost characterization that can be made is hydrocarbon reduction versus cost. This finding will also be shown in the affected industrywide analysis.

14.4.3 Projection to the Affected Industry

Exhibit 14-10, following Exhibit 14-9, shows the projection of vapor recovery costs to the affected industry in Tennessee. The estimates are based on the following assumptions:

- In Tennessee the affected bulk gasoline plants can be characterized by the model plant

Exhibit 14-9

U.S. Environmental Protection Agency
DESCRIPTION AND COST OF A MODEL BULK PLANT EQUIPPED WITH VAPOR CONTROL

Bulk Plant Characteristics	Model Bulk Plant
Throughput	4,000 gallons/day
Loading racks	1
Storage tanks	3
Account trucks	2
Compartment per account truck	4
Vapor control system	Alternative I
Bulk Plant Costs	
Installed capital cost[a]	$13,700
Annual direct operating costs @ 3 percent of installed cost	411
Annualized capital charges @ 25 percent of installed capital cost	3,425
Net annualized operating cost (not including gasoline credit)	3,836

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a. Assume $3,000 installed capital cost to modify one four compartment account truck. Does not include cost of $150 to install submerged fill pipe.

Source: Booz, Allen & Hamilton Inc.

Exhibit 14-10

U.S. Environmental Protection Agency

INDUSTRY COSTS OF VAPOR CONTROL SYSTEMS FOR AFFECTED BULK GASOLINE PLANTS IN TENNESSEE

Characteristics/Cost Item	Data
Number of facilities	2
Total annual throughput (millions of gallons)	3.2
Uncontrolled emissions (tons/year)	40
Emission reduction (tons/year)	30
Emissions after RACT control (tons/year)	10
Installed capital[a] ($, 1977)	27,700
Direct annual operating cost ($, 1977)	830
Annualized capital charges ($, 1977)	6,925
Annual gasoline credit[a] ($, 1977)	393
Net annualized cost ($, 1977)	7,362
Annualized cost per ton of emissions reduced ($ per ton)	245

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a. Include $300 to equip 2 bulk gasoline plants with submerged fill pipes.

b. Based on an estimated 10 percent of emissions reduced by converting from splash fill to submerged fill.

Source: Booz, Allen & Hamilton Inc.

- All affected bulk plants will implement the Control Alternative I vapor control system to comply with RACT

Actual costs to bulk plant operators may vary depending on the type of control alternative and manufacturer's equipment selected by each bulk plant operator.

Based on the above assumptions, the total cost to the affected industry for installing vapor recovery equipment is estimated to be $27,700. The amount of gasoline prevented from vaporizing using vapor control is valued at $393. Ten percent of total emissions can be credited to the bulk plant since installation of vapor control equipment may reduce emissions by an estimated 10 percent. The annualized cost per ton of emissions controlled is estimated to be $245 per ton.

14.5 DIRECT ECONOMIC IMPLICATIONS

This section presents the direct economic implications of implementing RACT controls at the two affected bulk gasoline plants in Tennessee including availability of equipment and capital; feasibility of the control technology; and impact on economic indicators, such as value of shipments, unit price (assuming full cost passthrough), state economic variables and capital investment.

14.5.1 RACT Timing

RACT must be implemented by 1982. This implies that bulk gasoline plant operators must have vapor control equipment installed and operating within the next three years. The timing requirements of RACT impose several requirements on bulk plant operators including:

- Determining appropriate vapor control system
- Raising capital to purchase equipment
- Generating sufficient income from current operations to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to insure that the system complies with RACT.

The sections which follow discuss the feasibility and the economic implications of implementing RACT within the required timeframe.

14.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Several bulk plants in the U.S. have attempted to implement vapor control systems with varying degrees of success. One bulk plant operator interviewed in Maryland implemented vapor recovery at a cost of $65,000 in 1974. The operator indicated that recent tests have shown the system operates well within the 90 percent recovery requirement of RACT.

This particular bulk plant was converted to bottom filling and completely vapor balanced. The plant's throughput was 20,000 gallons per day and included one loading rack and three account trucks. This plant would be characterized as installing a sophisticated Alternative III control system. The plant is also operated by a major oil company, so capital availability problems were minimized.

Bulk plants in the Houston/Galveston area, on the contrary, have implemented "bare bone" type control systems that were individually designed and installed at a bulk plant which was owned by a major oil company. No emission data are available to verify whether these systems are in compliance, but U.S. EPA estimates that these control systems are sufficient to meet the requirements of RACT. These systems are not marketed by any equipment manufacturer; therefore, their availability for widespread application is doubtful at the present time.

National adoption of RACT regulations will generate a demand for economical vapor control systems for bulk plants. It is, therefore, anticipated that off-the-shelf systems could be developed within the next three years that are similar to the control system implemented in the Houston/Galveston area; thus making equipment available.

A number of economic factors are involved in determining whether a specific bulk plant operator will be able to implement vapor control systems and still remain profitable. These include:

- Degree of competition
- Ability to pass on a price increase
- The current profitability of the plant
- Age of the plant
- State of repair of the plant
- Ownership--major oil company or private individual.

It is estimated that small bulk plants, with throughput less than 4,000 gallons per day, could experience a direct cost increase of nearly 0.3 cents per gallon if they implement RACT.[1] This may affect both affected bulk plants in Tennessee.

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[1] Estimated based on dividing net annual cost for model plant by annual throughput for a 4,000 gallon per day bulk gasoline plant. This assumes full cost passthrough.

One small bulk plant operator in Missouri reported during an interview that his gross profit margin per gallon of gasoline is 4 to 5 cents per gallon. His net profit margin is 0.5 cent per gallon. This operator stated that he plans to discontinue operations rather than comply with RACT. Again, sufficient data are not available to determine if this would be true for the two affected bulk plants in the state. In a previous study of the economics of vapor recovery for small bulk plants, a trend of declining profitability in bulk plant operations was identified.[1] If this trend continues, vapor control systems may not be affordable at marginal plants. Many bulk plants now operate at a profit only because their plants are fully depreciated. In the same study it was also determined that a large percentage of small bulk plants may not be able to raise sufficient capital to purchase vapor control equipment. Furthermore, it is estimated that the price of vapor control systems is likely to increase in the future at a rate greater than the GNP. One bulk plant operator stated that prices for vapor control have risen 30 percent over the past three years. Industry decline may continue and some bulk plant operators may cease operations because of their present financial condition and the additional financial burden of the RACT requirements.

The paragraphs which follow compare the affected statewide compliance costs of RACT control, in 1977 dollars, to various economic indicators.

14.5.3 Comparison of Direct Cost with Selected Direct Economic Indicators

This section presents a comparison of the net increase in the annualized operating cost of implementing RACT with the total value of gasoline sold from the affected bulk plants in the state, the value of wholesale trade in the state, and the unit price of gasoline.

The net increase in the annualized operating cost to the bulk gasoline plants due to RACT represents 2 percent of the total gasoline sold from affected bulk gasoline plants in the state. When compared to the statewide value of wholesale trade, these annualized cost increases are minimal. The impact on the unit price of gasoline varies with the bulk plant throughput.

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[1] Economic Analysis of Vapor Recovery Systems on Small Bulk Plants, EPA 340/1-77-013, September 1976.

14.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure and productivity.

For bulk gasoline plants that comply with the RACT requirements, additional manpower requirements are not likely to be required. Overall bulk gasoline plant industrial sector employment may continue to decline if the number of bulk gasoline plants operating in the state declines further. Based on the statewide estimates of number of employees and number of bulk plants, an average of approximately 5 jobs could be lost with the closing of a bulk plant. No estimate was made of whether the two affected bulk plants might close due to RACT.

The impact on the market structure for bulk plants differs significantly in urban and rural areas. The importance of bulk plants in the urban areas is apparently declining because of competition from retailers and tank truck terminals and may continue to decline regardless of RACT requirements.

The productivity of a specific bulk plant will be a function of the type of vapor control system installed. If a bulk plant converts to bottom filling along with vapor recovery, the productivity of the bulk plant should increase. However, some vapor control systems may decrease plant productivity if flow rates substantially decline, requiring longer times to load and unload trucks.

* * * *

Exhibit 14-11, on the following page, presents a summary of the findings of this chapter.

EXHIBIT 14-11

U.S. Environmental Protection Agency

SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR AFFECTED BULK GASOLINE PLANTS IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	2
Indication of relative importance of industrial section to state economy	Industry sales from affected bulk plants were 1.36 million. The estimated annual throughput was 3.2 million gallons.
Current industry technology trends	Only small percent of industry has new/ modernized plants
1977 VOC actual emissions	40 tons per year
Industry preferred method of VOC control to meet RACT guidelines	Top submerge fill and vapor balancing

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$27,700
Annualized cost (statewide)	$7,000 (approximately 0.5 percent of value of shipments)
Price	Assuming a "direct cost passthrough" industrywide—$0.0021 per gallon increase
Energy	Assuming full recovery of gasoline—net savings of 200 barrels annually
Productivity	No major impact
Employment	No major impact; however, for plants closing, potential average of 5 jobs lost per plant closed
Market structure	Regulation could further concentrate a declining industry. Many small bulk plants today are marginal operations; further cost increases could result in plant closings
Problem areas	Severe economic impact for small bulk plant operations. Control efficiency of cost effective alternative has not been fully demonstrated
VOC emissions after control	10 tons per year
Cost effectiveness	$245 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

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Stage I Vapor Recovery and Small Bulk Plants in Washington, D.C., Baltimore, Maryland, and Houston/Galveston, Texas, EPA 340/1-77-010, April 1977.

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Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA 905/2-78-001, April 1978.

Systems and Costs to Control Hydrocarbon Emissions from Stationary Sources, PB-236 921, Environmental Protection Agency, September 1974.

Control of Volatile Organic Emissions from Bulk Gasoline Plants, EPA 450/2-77-035, December 1977.

Hydrocarbon Control Strategies for Gasoline Marketing Operations, EPA 450/3-78-017.

Tennessee State Implementation Plans.

Memorandum, "Meeting with EPA and Others on Bulk Plant Vapor Recovery," National Oil Jobbers Council Mr. Bob Bassman, Counsel, March 21, 1978.

Letter to Mr. William F. Hamilton, Economic Analysis Branch, United States Environmental Protection Agency, from California Independent Oil Marketers Association, February 28, 1978.

Private conversation with Mr. Clark Houghton, Missouri Bulk Plant Operator.

Private conversation with Mr. D. L. Adams,
Phillips Petroleum, Towson, Maryland.

Private conversation with Mr. Robert Schuster,
bulk plant operator in Escondido, California.

Private conversation with Mr. Burton McCormick,
bulk plant operator in Santa Barbara, California.

"The Lundburg Letter," Pele-Drop, North Hollywood,
California.

Private conversation with Mr. William Deutsch, Illinois
Petroleum Marketers Association, Springfield, Illinois.

Conversations with Mr. Jerry Chalmers, South Carolina
Department of Health and Environmental Control.

Interviews with Tennessee state officials.

15.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT controls for the storage of petroleum liquids in fixed-roof tanks in Tennessee. The major sections of the chapter include:

- Specific methodology and quality of estimates
- Technical characteristics of fixed-roof tanks for storing petroleum liquids
- Profile of statewide fixed-roof tank industry and estimated annual VOC emissions
- Cost of controlling VOC emissions
- Economic impact.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of fixed-roof storage tanks, interviews with industry representatives and analysis of the findings.

15.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining:

- Technical characteristics of fixed-roof tanks
- Profile of fixed-roof tanks
- VOC emissions
- Cost of vapor control systems
- Economic impact of emission control for the storage of petroleum liquids in fixed-roof tanks.

The quality of these estimates is discussed in the last part of this section.

15.1.1 Technical Characteristics of Fixed-Roof Tanks

The technical characteristics of fixed-roof tanks and processes for controlling their emissions were obtained mainly from the RACT guideline entitled Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-4501/2-77-036, and from several other studies of fixed-roof tanks listed in the reference section of this report.

15.1.2 VOC Emissions and Profile of Fixed-Roof Tanks

The VOC emissions from petroleum liquid storage for each Air Quality Control Region were provided in the Tennessee State Implementation Plan. The plan shows emissions from petroleum liquid storage in three non-attainment counties: Davidson, Hamilton and Shelby.* The portion of the VOC emissions attributable to fixed-roof storage tanks and the number of tanks in each of the three counties were obtained from three sources:

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* The absence of petroleum liquid storage facilities in the remaining counties was not verified.

- The EPA final report, Hydrocarbon Control Cost-Effectiveness Analysis for Nashville, Tennessee, provided the estimated VOC emissions and the number of fixed-roof tanks in Davidson County.

- Appendix I of the State Implementation Plan provided the estimated VOC emissions and the number of fixed-roof tanks in Hamilton County.

- Total emissions from storage of gasoline and crude oil in fixed-roof tanks in Shelby County were obtained from the Memphis and Shelby County Health Department.

Since the capacity and throughput information were not available for Davidson and Shelby Counties, estimates were based upon the emissions, using emissions factors given in EPA AP-42 and an assumed turnover rate of 25 cycles per year.[1,2]

15.1.3 Cost of Vapor Control Systems

The costs of vapor control systems were developed by:

- Determining the type of control system

- Developing installed capital costs for each tank

- Developing total annualized costs of control systems for the number of tanks in the state including:
  - Installed capital cost
  - Direct operating costs
  - Annualized capital charges
  - Petroleum liquid credit
  - Net annualized cost

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[1] Based on throughput data for fixed-roof tanks in the State of Kentucky supplied by the Kentucky Department for Natural Resources and Environmental Protection.

[2] Since the contents of the tanks were not reported, the tanks were assumed to store gasoline and the corresponding emission factors were used.

- Aggregating costs to the total industry in Tennessee.

Costs were determined from analyses of the following studies:

- Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA 450/2-77-036
- Benzene Emission Control Costs in Selected Segments of the Chemical Industry, prepared for Manufacturing Chemists Association By Booz, Allen & Hamilton Inc., June 12, 1978

and from interviews with petroleum marketers' associations, petrochemical manufacturers and vapor control equipment manufacturers.

The extrapolation of the estimated cost of control to Tennessee required a profile of fixed-roof tanks for storing petroleum liquids in the State. These data were provided by the above mentioned sources in Section 15.1.2.

15.1.4 Economic Impact of Emission Control

The economic impact of emission control for equipping fixed-roof tanks used for storing petroleum liquids can be determined only in terms of the aggregated costs of controls. Since several industries use fixed-roof tanks, economic impacts on individual industries depend on the extent to which those industries must bear the increased cost burden. The economic impact analysis in this report is, therefore, limited to estimating aggregated costs of controls and qualitatively assessing the potential impacts of these costs on various industries.

15.1.5 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and eocnomic impact of implementing RACT controls for fixed-roof tanks in Tennessee. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 15-1, on the following page, rates each study output listed and the overall quality of the data.

Exhibit 15-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics		●	
Emissions		●	
Cost of emissions control		●	
Statewide costs of emissions		●	
Economic impact			●
Overall quality of data		●	

Source: Booz, Allen & Hamilton Inc.

15.2 TECHNICAL CHARACTERISTICS OF AND RACT GUIDELINES FOR FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS

The technical characteristics of fixed-roof tanks for storing petroleum liquids, the sources and types of VOC emitted by these tanks and the control measures for reducing VOC emission from fixed-roof tanks are described in the EPA guidelines series, Control of Volatile Organic Emissions from Storage of Petroleum Liquids in Fixed-Roof Tanks, EPA-450/2-77-036.

The proposed state regulations call for installation of an internal floating roof for fixed-roof tanks storing greater than 42,000 gallons of petroleum liquids with a true vapor pressure that exceeds 1.52 psi. The guidelines do not apply to storage tanks equipped with external floating roofs or to storage tanks having capacities less than 420,000 gallons used to store crude oil and condensate prior to lease custody transfer.[1]

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[1] "Custody transfer" means the transfer of produced crude oil and/or condensate, after processing and/or treating in the production operations, from storage tanks or automatic transfer facilities to pipelines or any other forms of transportation.

15.3 PROFILE OF FIXED-ROOF TANKS FOR STORING PETROLEUM LIQUIDS AND ESTIMATED VOC EMISSIONS

This section contains a profile of fixed-roof tanks used for storing petroleum liquids in Tennessee and the estimated annual VOC emissions from these tanks.

There are an estimated 17 fixed-roof tanks with greater than 42,000 gallons capacity in the State.[1] The total storage capacity of these tanks is approximately 11.03 million gallons and the annual throughput is estimated at appoximately 276.04 million gallons.

The VOC emissions (1977) for fixed-roof tanks in Tennessee are estimated to be 1,508 tons per year. Through the implementation of RACT guidelines, these emissions could be reduced by 90 percent to an estimated 151 tons per year.

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[1] Since the data on the content of the tanks were not available, it was assumed that all potentially affected tanks contained gasoline.

15.4 COST OF CONTROLLING VOC EMISSIONS

This section presents a cost analysis of equipping fixed-roof tanks used for storing petroleum liquids with internal floating roofs as a means for controlling VOC emissions.

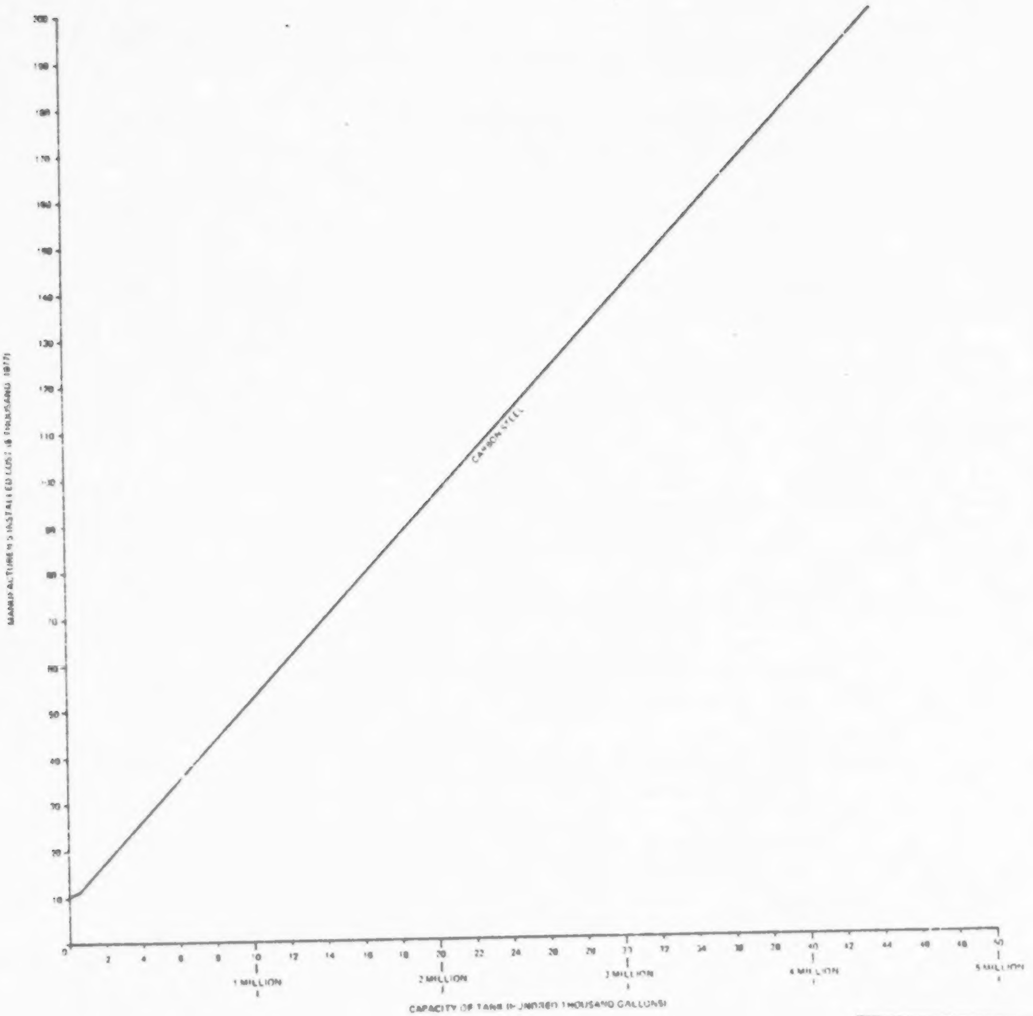
The cost factors for emission control equipment include:

- Installed capital cost, including parts and labor
- Annualized capital charges, estimated to be 25 percent of installed capital cost and including costs for depreciation, interest, maintenance, taxes and insurance
- Annual direct operating costs, estimated to be 2 percent of installed capital cost including costs for inspection and recordkeeping
- Annual petroleum liquid credit calculated by multiplying emission reduction by the volume of the petroleum liquid divided by the liquid density and multiplied by a value of $0.39 per gallon
- Net annualized costs, the sum of the annualized capital charges and direct operating costs less the petroleum credit.

Capital equipment costs were determined for each tank from the graph in Exhibit 15-2, on the following page. This graph was prepared by Booz, Allen based on interviews with petroleum refineries, petrochemical manufacturers, tank manufacturers and emission control equipment manufacturers. Total installed capital cost, including labor, is an estimated two times the value given on the graph. All costs are for 1977.

A summary of the aggregated cost for the control of emissions from petroleum liquids stored in fixed-roof tanks is shown in Exhibit 15-3, following Exhibit 15-2. The total installed capital costs for equipping approximately 17 fixed-roof tanks affected by RACT with internal floating roofs is approximately $1.074 million. The net annualized cost is approximately $117,000 taking into account a liquid petroleum credit of $173,000. The annualized cost per ton of emissions reduced is $86.

Exhibit 15-2
U.S. Environmental Protection Agency
INSTALLED COST OF SINGLE SEAL
FLOATING ROOF TANKS
(Prices Approximate)



Reproduced from
best available copy.

Source: Communications with Ultra-Float Inc.; Booz, Allen & Hamilton Inc. analysis

Exhibit 15-3

U.S. Environmental Protection Agency
VOC EMISSIONS CONTROL COSTS FOR STORAGE OF PETROLEUM LIQUIDS IN FIXED-ROOF TANKS IN TENNESSEE

SUMMARY

Plant Characteristics	
Number of tanks	17
Total capacity (millions of gallons)	11.033
Estimated annual throughput (millions of gallons)	276.04
Uncontrolled emissions (tons per year)	1,508
Emissions reduction (tons per year)	1,357
Emissions after control (tons per year)	151
Costs	
Installed capital cost ($, millions, 1977)	1.074
Annualized capital charges ($, millions, 1977)	0.269
Annual direct operating costs ($, millions, 1977)	0.021
Annual petroleum credit ($, millions, 1977)	0.173[a]
Net annualized cost ($, millions, 1977)	0.117
Annualized cost per ton of emissions reduced ($, 1977)	86

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[a] Assume value of petroleum liquid saved is $0.39 per gallon and density of petroleum liquid is 6.1 lbs. per gallon.

Source: Booz, Allen & Hamilton Inc.

15.5 DIRECT ECONOMIC IMPACT

This section discusses the economic impact of equipping fixed-roof tanks used for storing petroleum liquids with an internal floating roof to control VOC emissions. The impacts analyzed include: total cost statewide; identification of industries that may be affected and their ability to raise the capital needed for the controls.

- Installed Capital Cost in Tennessee. An estimated $1.074 million will be required in Tennessee to equip fixed-roof tanks for storing petroleum liquids with internal floating roofs. This represents approximately 1 percent of the value of petroleum liquid throughput from uncontrolled fixed-roof tanks in the State.

- Industries Affected. Fixed-roof tanks affected by RACT guidelines are owned by major oil companies, large petrochemical firms and bulk gasoline tank terminal companies. These companies are likely to meet the capital requirements and the source of capital is likely to be the company's traditional source of funds.

15.6 SECONDARY ECONOMIC IMPACTS

It is expected that secondary economic impacts as a result of implementing RACT guidelines in Tennessee will be minimal. Employment, worker productivity and market structure should remain unchanged.

* * * *

Exhibit 15-4 on the following page presents a summary of the findings of this chapter.

EXHIBIT 15-4

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR STORAGE OF PETROLEUM LIQUID IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected storage tanks	17
Indication of relative importance of industrial section to state economy	The annual throughput was an estimated 276 million gallons
Current industry technology trends	Internal floating roof tanks utilizing a double seal have been proven to be more cost effective
VOC emissions	1,508 tons per year
Preferred method of VOC control to meet RACT guidelines	Single seal internal floating roof

Affected Areas in Meeting RACT	Discussion
Capital investment (statewide)	$1.074 million
Annualized cost (statewide)	$117,000
Price	Assuming a "direct cost" passthrough—less than $0.0004 per gallon of throughput
Energy	Assuming 90 percent reduction of current VOC level, the net energy savings represent an estimated savings of 9,270 equivalent barrels of oil annually
Productivity	No major impact
Employment	No major impact
Market structure	No major impact
Problem area	Potential availability of equipment to implement RACT standard
VOC emission after control	150 tons per year
Cost effectiveness of control	$86 annualized cost/annual ton of VOC reduction

Source: Booz, Allen & Hamilton Inc.

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Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, EPA-905/2-78-001, U.S. Environmental Protection Agency, April 1978.

Revision of Evaporative Hydrocarbon Emission, PB-267 659, Radian Corp., August 1976.

Tennessee State Implementation Plans.

16.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT STAGE I FOR GASOLINE SERVICE STATIONS IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of implementing RACT Stage I controls pertaining to gasoline dispensing facilities[1] in the urban non-attainment areas of Tennessee. Tennessee RACT guidelines exempt facilities which dispense less than 260,000 gallons[2] of gasoline per year. In addition, under RACT guidelines, only three counties are classified as urban non-attainment areas. They are: Davidson, Hamilton, and Shelby counties.

The impact of RACT in these counties is investigated in six sections as follows:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation of the industry
- Cost and hydrocarbon reduction benefit evaluations for Stage I RACT requirements
- Direct economic implications
- Selected secondary economic impacts.

Each section presents detailed data and findings based on analyses of the RACT guidelines, previous studies of gasoline service station vapor recovery, interviews and analysis.

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[1] Gasoline dispensing facility is a generic term which encompasses both retail facilities and private outlets. The latter are primarily establishments maintained by governmental, commercial or industrial consumers for their own fleet operations. The latter category also includes rural convenience stores, parking garages, marinas and other retail outlets not classified as service stations.

[2] The proposed regulation exempts facilities with less than 260,000 gallons throughput per year or with storage tanks having less than 2,000 gallons capacity. Here it is assumed that 260,000 gallons is the relevant constraint.

16.1 SPECIFIC METHODOLOGY

This section describes the methodology for determining estimates of:

- Industry statistics
- VOC emissions
- Processes for controlling VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control

for gasoline dispensing facilities in the State of Tennessee.

The quality of the estimates based on a three-point scale is described in detail in the latter part of this section.

16.1.1 Industry Statistics

The base year of the analysis is 1977 and all industry statistics are reported accordingly. When hard data for the base year are not available, appropriate scaling factors are applied to existing confirmed data to derive base year estimates.

To derive the total number of gasoline dispensing facilities in the three non-attainment counties a two-stage procedure is used. First, the number of statewide retail service stations is identified[1] and the figure is then scaled by a factor of 1.37[2] to produce an estimate of the number of private dispensing facilities. Next, these two statewide totals are disaggregated to the county level using coefficients developed from a Bureau of Census publication.[3] In addition to providing a basis for estimating the total number of dispensing facilities at the county level, the census publication is also used to calculate total county employment levels.

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[1] National Petroleum News Fact Book, 1978, p. 105.

[2] The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, Department of Labor, OSHA, C79911, March 1978, pp. 4-7.

[3] County Business Patterns 1976: Tennessee, U.S. Department of Commerce, CBP-76-12, 1978.

Finally, to derive the volume of gasoline sold in the non-attainment counties, existing data on state sales totals[1] are disaggregated using coefficients reflecting the ratio of county establishments to state establishments. A value is assigned to this sales volume using the 1977 average national service station price (50.7¢/gal. excluding tax).[2]

16.1.2 VOC Emissions

The Illinois EPA estimated VOC emissions for gasoline service stations by applying an emission factor to the 1977 gasoline throughput. This emission factor and procedure were used to calculate emissions in Tennessee.

16.1.3 Processes for Controlling VOC Emissions

Processes for controlling VOC emissions from gasoline service stations are described in "Design Criteria for Stage I Vapor Control Systems--Gasoline Service Stations." This document provides the base data on alternative methods available for controlling VOC emissions from gasoline service stations. In addition, several studies of VOC emission control were analyzed and interviews with petroleum trade associations, gasoline service station operators and vapor control equipment manufacturers were conducted to ascertain the most likely types of equipment which would be used in gasoline service stations in Tennessee. The specific studies analyzed were: Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042; A Study of Vapor Control Methods for Gasoline Marketing Operations, PB-246-088, Radian Corporation; Reliability Study of Vapor Recovery Systems at Service Stations, EPA-450/3-76-001; Technical Support Document, Stage I Vapor Recovery at Service Stations, draft, Illinois Environmental Proctection Agency.

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[1] Federal Highway Administration Forms, MF 25, 26, 21.

[2] National Petroleum News Fact Book, 1978, p. 100.

16.1.4 Cost of Vapor Control Systems

The cost of vapor control systems were estimated by:

- Developing costs of two different control systems for a model service station including:
  - Installed capital cost
  - Direct operating costs
  - Annualized capital charges
  - Gasoline credit
  - Net annualized cost
- Determining the mix of control systems likely to be used in the study area
- Extrapolating the model service station costs to the service stations in the study area.

Based on the analyses of the studies listed previously and interviews with petroleum marketers' associations, gasoline service station operators and vapor control equipment manufacturers, it was estimated that 75 percent of the gasoline dispensing facilities would install coaxial or concentric vapor balance systems and the remaining 25 percent would install the two-point vapor balance system. Costs were also determined from the data obtained from these sources.

16.1.5 Economic Impacts

The economic impacts were determined by analyzing the lead time requirements needed to implement RACT; assessing the feasibility of instituting RACT controls in terms of capital and equipment availability; comparing the direct costs of RACT control to various county economic indicators; and assessing the secondary impacts on market structure, employment and productivity resulting from implementation of RACT controls.

16.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, costs, and economic impact of implementing RACT controls on gasoline service stations. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 16-1, on the following page, rates each study output and the overall quality of the data.

EXHIBIT 16-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	X		
Emissions		X	
Cost of emissions control		X	
Countywide costs of emissions			X
Economic impact		X	
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

16.2 INDUSTRY STATISTICS

Industry characteristics, statistics and business trends for gasoline service stations are presented in this section. The discussion includes a description of the number of facilities and their characteristics, a comparison of the size of the service station industry to state economic indicators, an historical characterization and description of the industry and an assessment of future industry patterns. Data in this section form the basis for assessing the impact on this industry of implementing RACT to VOC emissions from gasoline dispensing facilities in Tennessee.

16.2.1 Size of Industry

In 1977, the three non-attainment counties contained an estimated 1332 retail gasoline dispensing facilities. Of these 1332 facilities, an estimated 59 percent[1] or 786 had annual throughputs in excess of 260,000 gallons. Put differently, 41 percent of retail facilities could be exempted under the proposed regulations. In addition to the 1,332 retail facilities, there are an estimated 1,825 private dispensing facilities. Of these 1,825 outlets, only about 1 percent or 18 outlets are estimated to have annual throughputs in excess of the proposed exemption. Together these 804 private and retail establishments dispensed an estimated 651,300,000 gallons of gasoline valued at $330,200,000 in 1977. These same stations employed approximately 4,600 workers. Total capital investments associated with the gasoline dispensing facilities could not be identifed. For further details the reader is referred to Exhibit 16-2 on the following page.

16.2.2 Comparison of Industry to State Economy

Employment and sales are used as reference indicators in order to gain a perspective on the economic significance of the gasoline dispensing industry. The estimated 4,600 employees and $330,200,000 in sales constitute approximately one percent of the civilian labor force and 5.5 percent

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[1] U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, Appendix tables B-1 and B-2.

EXHIBIT 16-2
U.S. Environmental Protection Agency
INDUSTRY STATISTICS FOR GASOLINE SERVICE STATIONS IN TENNESSEE

Number of Facilities Potentially Affected		Number of Employees			
Retail Dispensing Facilities	Private Dispensing Facilities	Retail	Private	Sales ($Billion, 1977)	Gasoline Sold (Billions of Gallons)
786[a]	18[b]	4,568[c]	36[d]	0.330[e]	0.651[f]

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a. National Petroleum News Fact Book, 1978. County Business Patterns 1976: Tennessee, The Economic Impact of Vapor Reocvery Regulations on the Service Station Industry.

b. Includes gasoline dispensing facilities such as marinas, general aviation facilities, commercial and industrial gasoline consumers and rural convenience store operations with gas pumps.

c. Estimate based on the ratio of the number of employees to the number of establishments (scaled appropriately) in the three counties as of 1976.

Davidson	6.76 employees per retail outlet
Hamilton	4.42 employees per retail outlet
Shelby	5.79 employees per retail outlet

(Source: U.S. Department of Commerce, Bureau of Census, County Business Patterns 1976: Tennessee, CBP-76-12, 1978)

d. Estimate based on two employees per facility.

e. Number of gallons of motor gasoline sold in 1977 multiplied by the national service station price in 1977 (50.7¢/gallon), National Petroleum News Fact Book, 1978.

f. Estimate based on Federal highway statistics for 1977.

Source: Booz, Allen & Hamilton Inc.

of retail trade during 1977 in the three counties. In evaluating these percentages, it should be remembered that transportation is a vital linking element in the economy and any significant disruption to the gasoline dispensing sector could have indirect consequences for other sectors of the economy.

16.2.3 Characterization of the Industry: Structure and Trends

Gasoline dispensing establishments are the final distribution point in the petroleum marketing network. Exhibit 16-3 shows the position of both retail and private dispensing facilities with the former located in the bottom row and the latter primarily in the source marked "Commercial/Industrial Consumer Accounts." As the graphic indicates, all petroleum marketers retail their gasoline through one of the following type operations:

- Direct-salary operation: supplier-"controlled"/supplier-operated
- Lessee dealer: supplier-"controlled"/lessee-dealer operated
- Open dealer: dealer-"controlled"/dealer-operated
- Convenience store.

According to this classification, the retail gasoline dispensing sector has the following dimensions: 18 percent direct outlets, 5.4 percent convenience stores, 46.9 percent lessee dealers and 29.7 percent open dealers.* See Exhibit 16-4 for more details.

By way of contrast the private dispensing establishments have the following breakdown by end use: agriculture trucking and local service, government, taxis, school busses, and miscellaneous. See Exhibit 16-5 for more details.

Regardless of ownership pattern or end-use category, gasoline marketing is characterized by high fixed costs, with operations varying by degree of labor intensity. Conventional service stations (service bay with mechanics on duty and nongasoline automotive items available) are the most labor intensive, while self-service "gas and go" stations exemplify low labor intensity.

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* U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p. 58.

EXHIBIT 16-4
U.S. Environmental Protection Agency
U.S. RETAIL GASOLINE DISPENSING FACILITIES

% TOTAL OUTLETS

	Direct Outlets[a]	Convenience Stores	Leasee Dealer[b]	Open Dealer[c]	Total Directly Supplied
Major Oil Company	3.5	0.4	28.2	15.7	47.8%
Regional Refiner	2.3	0.1	5.3	1.1	8.8%
Independent Marketer/"Super Jobber"	9.3	4.3	2.5	0.6	16.7%
Small Jobber	2.9	0.6	10.9	12.3	26.7%
% Total Outlets	18.0%	5.4%	46.9%	29.7%	100.0%
Total Number of Outlets	32,070	9,600	83,690	53,030	178,390

a Company "investment"/company operated
b Company "investment"/leasee dealer
c Dealer "investment"/dealer operated

Source: U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p. 58.

EXHIBIT 16-5
U.S. Environmental Protection Agency
U.S. PRIVATE GASOLINE DISPENSING FACILITIES

End-Use Sector	Number of "Private" Gasoline-Dispensing Outlets	Annual Gasoline Consumption	% Total U.S. Private Gasoline Volume	% Total U.S. Gasoline Volume
Agriculture	32,600	3,801.3	15%	3%
Trucking and local service	21,900	5,241.6	21%	5%
Government	85,450		11%	2%
- Federal		227.6	0.9%	
- Military		174.1	0.6%	
- Other[a]		2,266.4	9.0%	
Taxis	5,380	882.1	3%	0.8%
School Busses	3,070	144.7	1%	0.1%
Miscellaneous[b]	94,530	12,497.2	49%	11%
Total Non-Service Station Segment	242,930	25,235.0	100%	23%
Retail Service Station Segment	178,390	84,412.0	___	77%
All Segments —	421,320	109,647.0		100%

[a] State and municipal governments.

[b] Auto rental, utilities, and other.

Source: U.S. Department of Labor, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p.47.

Finally, no discussion of the industry would be complete without a characterization of major trends. The number of gasoline dispensing facilities, and in particular the retail service stations, has been declining nationally since 1972. At the same time throughput per station has been rising reflecting the switch to high volume self-service "gas and go" establishments.[1] This trend also appears in Tennessee and is predicted to continue. In 1972 there were 5,157 service stations and in 1977 this number fell to 4,017.[2]

16.2.4 Gasoline Prices

Gasoline prices vary among types of gasoline stations within a geographical area. Convenience stores are apt to have higher pump prices than large self-service "gas and go" stations. The pump price less the dealer tank wagon price represents the gross margin on a gallon of gasoline. Retail gasoline service station operating costs then must come out of the gross margin for gasoline as well as the gross margin for other products which may be sold at the service station. Operating costs vary substantially among the various types of service stations. It is reported that some service stations operate with nearly zero net margin or profit on the sale of gasoline, while others may enjoy up to four to five cents profit per gallon. Insufficient detail is available on service stations in Tennessee to present a thorough analysis of existing price structures and degree of competition in the industry within the state.

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[1] Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042, November 1976, p. 2. By 1980 one-half of all retail gasoline stations are expected to be self-service.

[2] National Petroleum News Fact Book, 1978, p. 105.

16.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on gasoline dispensing outlet operations, estimated VOC emissions from these operations in the non-attainment areas, the extent of current control in use, the vapor control requirements of RACT and the likely alternatives which may be used for controlling VOC emissions from gasoline dispensing facilities in Tennessee.

16.3.1 Gasoline Dispensing

Gasoline service stations are the final distribution point in the gasoline marketing network. Taking retail and private outlets together the average monthly throughput per station in the three counties is 39,500 gallons. These facilities are all subject to RACT regulations and will be required to comply with Stage I vapor control by November 1, 1981.

16.3.1.1 Facilities

Equipment at gasoline dispensing facilities includes: gasoline storage tanks, piping and gasoline pumps. The most prevalent type of gasoline storage tank is the underground tank. It was assumed that there are typically three storage tanks per facility. Gasoline is dispensed to motor vehicles through pumps and there may be anywhere from one to twenty pumps per facility. Stage I vapor control regulations apply to the delivery of gasoline to the facility and the subsequent storage in underground tanks.

16.3.1.2 Operations, Emissions and Controls

Uncontrolled VOC emissions at dispensing facilities come from loading and unloading losses from tank trucks and underground tanks, refueling losses from vehicle tanks and breathing losses from the underground tank vent. Stage I vapor control applies to tank truck unloading and working and breathing losses from underground storage tanks.

Tank trucks are unloaded into underground storage tanks either by splash loading or submerged loading. Splash loading results in more emissions than submerged loading.

More specifically, losses consist of:

- Organic liquid that evaporates into the air that is drawn in during the withdrawal of the tank compartment contents
- Losses from refilling the underground tank that occur as vapors are displaced from the tank
- Vapors vented into the atmosphere from underground storage tanks as a result of changes in temperature and pressure.

Exhibit 16-6 shows the estimated emissions in tons per year from all dispensing facilities in non-attainment counties. To arrive at this estimate it is assumed that 90 percent[1] of all storage tank loading is by the submerge fill method and 10 percent by the splash fill method. Given this assumption, emissions based on throughput are estimated to be 2,514 tons.

16.3.2 RACT Guidelines

The RACT guidelines for Stage I VOC emission control from gasoline service stations require the following controls:

- Submerged fill of gasoline storage tanks
- Vapor balancing between the truck and the gasoline storage tank
- Proper operation and maintenance of equipment.

Exhibit 16-7 summarizes the RACT guidelines for VOC emissions control from gasoline service stations.

16.3.3 Selection of the Most Likely RACT Control Techniques

Stage I control of VOC emissions from gasoline dispensing facilities can be achieved by using vapor balancing between the unloading of incoming tank trucks and the gasoline storage tank and by submerged filling of storage tanks.

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[1] Source: Booz, Allen interviews with industry representatives.

EXHIBIT 16-6
U.S. Environmental Protection Agency
VOC EMISSIONS FROM GASOLINE IN THE STATE OF TENNESSEE

Estimated Number of Facilities	Average Yearly Throughput (Millions of Gallons)	Total Emissions[a] (Tons/Year)
804	651	2,514

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[a] Splash fill emissions: 11.5 lbs/1000 gallons throughput. Submerge fill emissions: 7.3 lbs/1000 gallons throughput, assumes no vapor balancing with either method.

Source: Booz, Allen & Hamilton Inc.

EXHIBIT 16-7

U.S. Environmental Protection Agency
VOC EMISSION CONTROL TECHNOLOGY FOR GASOLINE DISPENSING FACILITIES

Facilities Affected	Sources of Emissions	RACT Control Guidelines
Gasoline service stations and gasoline dispensing facilities	Storage tank filling and unloading tank truck	Stage I vapor control system, i.e., vapor balance system which returns vapors displaced from the storage tank to the truck during storage tank filling and submerge filling; instructions to operator of facility on maintenance procedures; repair and replacement of malfunctioning or worn equipment; maintenance of meters and test devices

Source: Regulatory Guidance for Control of Volatile Organic Compound Emissions from 15 Categories of Stationary Sources, pp. 28-31.

There are alternative means of achieving vapor balance based primarily on the method of connecting the vapor return line to the gasoline storage tank. The two primary methods for connecting vapor return lines are the two-point connection and coaxial or concentric connection (often referred to as tube-in-tube connection). The two-point connection method involves using two risers with the storage tank: one for fuel delivery and the other for returning vapors to the tank truck. The coaxial system uses a concentric liquid vapor return line and thus requires only one tank riser. EPA tests have shown the two-point system to be more effective than the coaxial system in transferring displaced vapors, but at the same time the two-point system is more expensive. It is judged that 25 percent[1] of gasoline dispensing facilities will install the two-point system, bearing a higher installed cost but achieving greater efficiency. Submerged fill is required by Stage I vapor control. It is achieved by using a drop tube extending to within six inches of the storage tank bottom.

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[1] Source: Booz, Allen interviews with industry representatives.

16.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR STAGE I RACT REQUIREMENTS

Costs for VOC emission control equipment are presented in this section. The costs for a typical gasoline service station are described, followed by an extrapolation to the urban non-attainment county industry.

16.4.1 Costs for Vapor Control Systems

The costs for vapor control systems were developed from information provided by petroleum marketing trade associations and from previous cost studies of gasoline dispensing facilities. These costs are summarized for a typical gasoline dispensing facility in Exhibit 16-8. The monthly throughput of an affected retail facility averages out at 67,000 gallons or 28,000 gallons above the average for all retail facilities in the United States.[1] Though Tennessee facilities are above the U.S. average, in general, service station equipment requirements (number of storage tanks) are not very sensitive to throughput over a large gallon range. Therefore, it appears that Tennessee facilities should be quite similar to the prototype facility described in Exhibit 16-8. Given this observation, Stage I vapor control costs have been estimated as follows.

Capital costs of installing the two-point vapor-balancing equipment at existing service stations are about $2,000 per station. This cost includes equipment costs ($300-$500) and installation ($1,300-$1,600).[2] The installed capital cost for a coaxial or concentric system is reported by U.S. EPA to be $150 to $200 per tank, including parts and labor. Annualized capital costs are estimated at 25 percent of installed capital cost and include interest, depreciation, taxes and maintenance.

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[1] U.S. Department of Labor, OSHA, The Economic Impact of Vapor Recovery Regulations on the Service Station Industry, C-79911, March 1978, p. 29.

[2] Air Pollution Control Technology Applicable to 26 Sources of Organic Compounds, U.S. Environmental Protection Agency, May 27, 1977. (This cost includes excavation and construction of manifolded storage tanks.)

EXHIBIT 16-8
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL COSTS FOR A TYPICAL RETAIL GASOLINE DISPENSING FACILITY

Description of Model Gasoline Station

Monthly throughput (gallons)	39,000[a]
Number of storage tanks	3[b]

Costs
($, 1977)

	Two Point System	Coaxial or Concentric System
Installed capital	2,000[c]	600
Annualized capital charges[d]	500	150
Direct operating cost	0	0
Annualized cost[e]	500	150

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[a] 39,000 is the national average. In Tennessee's non-attainment county the average is 67,000 for retail dispensing outlets, 8,220 for private outlets and private outlets.

[b] In private dispensing outlets, the number of tanks is assumed to be one as opposed to three. On the average, private stations have monthly throughput flows of only 22 percent of throughput in retail service stations.

[c] Includes cost of repaving but does not account for lost sales due to down time.

[d] Twenty-five percent of installed capital cost. Includes depreciation, interest, taxes, insurance and maintenance.

[e] Does not include credit for recovered gasoline.

Source: Booz, Allen & Hamilton Inc.

Based on these figures, the annualized cost[1] at a typical retail gasoline dispensing facility with 67,000 gallons/month throughput is estimated to be $500 for the two-point system and $150 for the concentric or coaxial system. It is worth noting that direct operating costs should not increase due to Stage I controls and thus the annualized cost will reflect only the capital charges associated with the control equipment.

In addition to the cost incurred at the gasoline dispensing facility, there are also the costs of vapor balancing borne by the owners of the tank trucks. The costs to bulk gas plants and terminals of Stage I vapor modifications of fleet trucks have been discussed in other chapters. Here the focus is on independent fleet operators subject to RACT vapor controls. By approximating the total number of tank trucks needed to service the gasoline dispensing facilities in the non-attainment counties, and by subtracting from this total the estimated number of trucks controlled by bulk terminals and gas plants, the size of the independent fleet is derived. Booz, Allen estimates that roughly 374 tank trucks require vapor modification.[2]

The cost of vapor control modification on trucks is estimated to be between $2,000 and $7,200 depending on whether top or bottom loading methods are used. For purposes of this analysis, it is assumed that the less expensive top loading method will be used, and that this system can be installed at a cost of $3,000 per truck. At 374 trucks total cost is $1,112,000. Annualized capital costs are estimated at 25 percent of installed capital cost and include: interest, depreciation, taxes and maintenance. Direct operating costs are assumed to be zero. See Exhibit 16-9 on the following page for more details.

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[1] Gasoline recovery credit has not been accounted for here, but will be when the results are extrapolated to the countywide industry.

[2] U.S. Environment Protection Agency, Survey of Gasoline Tank Vehicles and Rail Cars, EPA-68-02-2606, Preliminary Draft, pp. 1-3 and 2-10. Total stock of tank trucks is estimated to be 85,000. Booz, Allen estimates that statewide there are 1902 trucks and in non-attainment areas 628. Of these 628, it is estimated that 254 trucks are controlled by the bulk plants and terminals.

EXHIBIT 16-9
U.S. Environmental Protection Agency
STAGE I VAPOR CONTROL COSTS FOR A TYPICAL GASOLINE DISPENSING TRUCK

Costs
($, 1977)

	Top Loading Method
Installed capital[a]	3,000
Annualized capital charges[b]	750
Direct operating cost	0
Annualized cost	750

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[a] Booz, Allen interviews with equipment manufacturers.

[b] 25 percent of installed capital cost. It includes depreciation, interest, taxes, insurance and maintenance.

Source: Booz, Allen & Hamilton Inc.

16.4.2 Extrapolation to the Industry in Non-Attainment Areas

Exhibit 16-10 shows the extrapolation of vapor control costs to the non-attainment area-wide industry. Costs include truck modifications and vapor control at the gasoline dispensing facilities. It should be noted that actual costs to the operators of trucks and gasoline dispensing outlets may vary depending on the control method and specific equipment selected.

The total cost to the industry of installing vapor control equipment is estimated to be approximately $1,875,000[1]. The amount of gasoline prevented from vaporizing by converting to submerged filling of the gasoline storage tank is estimated to be worth approximately $22,700. Based on these estimates, the annual cost per ton of emissions controlled was $186.00 per ton.

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[1] The figure may be understated if the regulation calls for control of all storage tanks larger than 2000 gallons rather than the throughput exemptions applied in this analysis. Preliminary data suggest that in Davidson County perhaps 25 percent of all storage tanks are smaller than 2000 gallons in capacity. If this is true and if Davidson is permitted to use the 2,000 gallon rule, then total capital costs will rise by $149,000.

EXHIBIT 16-10
U.S. Environmental Protection Agency
NON-ATTAINMENT AREA COSTS FOR STAGE I VAPOR CONTROL OF GASOLINE DISPENSING FACILITIES

SUMMARY OF COSTS

Number of facilities	804
Total annual throughput (billions of gallons)	0.651
Uncontrolled emissions (tons/year)	2,514
Emissions reduction (tons/year)	2,388[a]
Uncontrolled emissions (tons/year)	126
Installed capital ($ millions)	1.875
• dispensing facilities	0.753
• tank trucks	1.122
Annualized capital cost ($ millions)	0.468
• dispensing facilities	0.188
• tank trucks	0.280
Annual gasoline credit ($ millions)	0.023[b]
Net annualized cost ($ millions)	0.445
Net annualized cost per ton of emissions reduced ($ per ton/year)	$186

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[a] Estimate based on 95 percent reduction in emissions.

[b] Gasoline credit to dispensing outlets is based on the conversion from splash to submerged filling. The actual formula relates throughput in splash fill facilities to potential captured vapors resulting from equipment conversion, and values the recoverable gasoline at its retail selling price (50.7¢/gallon). Bulk terminals also receive a gasoline credit for the recovered vapors brought back by tank trucks. This gasoline is estimated to be worth $327,000 when valued at the bulk wholesale price (42¢/gallons).

Source: Booz, Allen & Hamilton Inc.

16.5 DIRECT ECONOMIC IMPLICATIONS

This section discusses the direct economic implications for the non-attainment counties of implementing Stage I RACT controls.

16.5.1 RACT Timing

RACT must be implemented statewide by November 1, 1981. This means that gasoline service station operators must have vapor control equipment installed and operating within the next three years. The timing deadlines of RACT impose several requirements on service station operators including:

- Determining the appropriate method of vapor balancing
- Raising capital to purchase equipment
- Generating sufficient income from current operators to pay the additional annual operating costs incurred with vapor control
- Acquiring the necessary vapor control equipment
- Installing and testing vapor control equipment to ensure that the system complies with RACT.

16.5.2 Feasibility Issues

Technical and economic feasibility issues of implementing RACT controls are discussed in this section.

Gasoline service stations in several air quality control regions of the U.S. have successfully implemented Stage I vapor control systems.

State adoption of Stage I RACT regulations will generate additional demand for the vapor control systems for gasoline service stations. However, it is estimated that off-the-shelf systems will be readily available within the next three years, thus making equipment available.

A number of economic factors are involved in determining whether a specific establishment will be able to implement vapor control systems and still remain profitable. These include:

- Ability to obtain financing
- Ownership—major oil company or private individual
- Ability to pass on a price increase
- The current profitability of the establishment
- Age of the establishment.

A major finding in a study on gasoline service station vapor control was that small service stations could have problems raising the necessary capital to purchase and install vapor control equipment. The inability to raise the necessary capital to install vapor control equipment could cause the closing of some service stations.[1]

Service stations that are owned by major oil companies may have better access to capital than privately owned service stations. A private service station owner may have to borrow capital from local banks, friends or relatives, whereas a station owned by a major oil company may receive funding out of the oil company's capital budget.

It is estimated that small gasoline service stations with throughput less than 30,000 gallons per month will experience a cost increase of nearly 0.10 cents per gallon to implement RACT, using the two-point vapor balance system. However, most of these facilities will be exempted in Tennessee. Larger service stations will experience a cost increase only one-fifth as much. But regardless of actual size the smaller stations will be at a competitive disadvantage in terms of passing on a price increase.

Recent experience indicates that temporary disruption due to Stage I RACT control can have serious impacts on the service stations' profitability. In an interview, the Greater Washington/Maryland Service Station Association reported that several service stations experienced a loss of business for up to three weeks while Stage I vapor control was being installed. Service station driveways were torn up, greatly restricting access to pumps. In some instances, oil company owned service stations were sold or closed down because the oil companies did not want to expend funds for vapor control at marginally profitable operations.

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[1] Economic Impact of Stage II Vapor Recovery Regulations: Working Memoranda, EPA-450/3-76-042, November 1976.

The older service stations reportedly will experience greater costs than new service stations when implementing Stage I vapor control requirements. This is because older stations will have more extensive retrofit requirements and will probably experience more temporarily lost business during the retrofit.

The number of gasoline service stations has been declining nationally over the past few years for a number of reasons, reflecting a trend towards reducing overhead costs by building high throughput stations. This trend is likely to continue whether or not vapor control is required. Implementation of Stage I RACT control may simply accelerate this as marginal operators may opt not to invest in the required capital equipment. Sufficient data for Tennessee are not available to quantify the magnitude of this impact.

16.5.3 Comparison of Direct Cost With Selected Direct Economic Indicators

The net increase in the annualized cost to the gasoline service station industry from RACT represents 0.05 percent of the value of the total gasoline sold in the affected facilities in the urban non-attainment counties. Compared to the countywide value of retail trade, this annual cost increase would be insignificant. The impact on the unit price of gasoline varies with the gasoline service station throughput. As mentioned in the preceding section, the small stations, with less then 30,000 gallons per month throughput, may experience an annualized cost increase of up to 0.10 cents per gallon of gasoline sold, whereas the larger service stations may experience an annualized cost increase only one-third as large.

16.6 SELECTED SECONDARY ECONOMIC IMPACTS

This section discusses the secondary impact of implementing RACT on employment, market structure, and gasoline station operation.

Employment is expected to decline, if a number of small marginally profitable gasoline service stations cease operating rather than invest capital for compliance with RACT. Based on the countywide estimates of number of employees and the number of facilities, approximately three jobs will be lost with the closing of each gasoline dispensing outlet. No estimate was made of the total number of facilities that may close due to RACT.

The market structure is not expected to change significantly because of Stage I vapor control requirements. The dominant industry trend is towards fewer stations with higher throughputs. This trend will continue with or without RACT. Those marginal facilities which do close because of RACT will merely enhance the existing industry trend towards greater concentration.

The productivity impact on a specific service station operation is expected to be slight. Fill rates for loading gasoline storage tanks may marginally decline if coaxial or concentric vapor hose connections are used.

* * * *

Exhibit 16-11, on the following page, presents a summary of the findings of this report.

EXHIBIT 16-11

U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR GASOLINE DISPENSING FACILITIES IN THE STATE OF TENNESSEE

Current Situation	Discussion
Number of potentially affected facilities	804 in the 3 urban non-attainment counties.
Indication of relative importance of industrial sector to county economy.	3 county industry sales from the affected facilities are $0.330 million with a yearly throughput of 0.651 billion gallons
Current industry technology trends	Number of stations has been declining and throughput per station has been increasing. By 1980, one-half of stations in U.S. are predicted to become totally self-service
1977 VOC emissions (actual)	2514 tons per year from tank loading operation
Industry preferred method of VOC control to meet RACT guidelines	Submerged fill and vapor balance
Assumed method of control to meet RACT guidelines	Submerged fill and vapor balance

Affected Areas in Meeting RACT	Discussion
Capital investment (3 counties)	$1.9 million
Annualized cost (3 counties)	$0.47 million (approximately 0.1 percent of the value of gasoline sold)
Price	Assuming a "direct cost pass-through"--less than $0.001 per gallon of gasoline sold in the 3 counties.
Energy	Assuming full recovery: 770,300 gallons/year (15,900 barrels of oil equivalent) saved[a]
Productivity	No major impact
Employment	No major impact
Market structure	Compliance requirements may accelerate the industry trend towards high throughput stations (i.e., marginal operations may opt to shut down)

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[a] One gallon of gasoline has 125,000 BTU's. One barrel of oil equivalent has 6,050,000 BTU's.

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16-20

17.0 THE ECONOMIC IMPACT OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF TENNESSEE

This chapter presents a detailed analysis of the impact of implementing RACT for use of cutback asphalt in the State of Tennessee. The impact of RACT in this state is investigated in five sections as follows:

- Specific methodology and quality of estimates
- Industry statistics
- The technical situation in the industry
- Cost and hydrocarbon VOC reduction benefit evaluations for RACT requirements
- Economic impacts

Each section presents detailed data and findings based on review of the RACT guidelines, previous studies of the use of cutback asphalt, interviews and analysis.

17.1 SPECIFIC METHODOLOGY AND QUALITY OF ESTIMATES

This section describes the methodology for determining:

- Industry statistics
- VOC emissions
- Control of VOC emissions
- Cost of controlling VOC emissions
- Economic impact of emission control
- Data quality

for the use of cutback asphalt in Tennessee.

17.1.1 Industry Statistics

Industry statistics on the use of cutback asphalt were obtained from the U.S. Bureau of Mines. Sales in tons were available for 1977. The value of shipments was calculated by applying an average unit price of 36 cents per gallon.

17.1.2 VOC Emissions

VOC emissions from the use of cutback asphalt in Tennessee were calculated by multiplying the emission factors for cutback asphalt by the number of tons of asphalt used. The emission factor for slow cure asphalt is 0.078 tons per ton, for medium cure asphalt 0.209 tons per ton, and for rapid cure asphalt 0.20 tons per ton.[1]

17.1.3 Process for Controlling VOC Emissions

The process for controlling VOC emissions from the use of cutback asphalt is described in Control of Volatile Organic Compounds From the Use of Cutback Asphalt, EPA-450/2-77-037, and Air Quality and Energy Conservation Benefits from Using Emulsions to Replace Cutbacks in Certain Paving Operations, EPA-450/12-78-004. Interviews were conducted with asphalt trade associations, asphalt producers, and government agencies to gather the most up-to-date information on: costs for cutback asphalt and asphalt emulsions, the feasibility of using emulsions in place of cutback asphalt and the associated cost implications. Other sources of information were "Mineral Industry Surveys," U.S. Bureau of Mines; "Magic Carpet, the Story of Asphalt," The Asphalt Institute; "Technical Support for RACT Cutback Asphalt," State of Illinois; "World Use of Asphalt Emulsion," paper by Cyril C. Landis, Armak Company, "A Brief Introduction to Asphalt and Some of Its Uses," The Asphalt Institute; and "Asphalt: Its Composition, Properties and Uses," Reinhold Publishing Corporation.

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[1] Control of Volatile Organic Compounds from the Use of Cutback Asphalt, EPA-4502-77-037, pp. 1-3.

17.1.4 Cost of Vapor Control

The costs for control of VOC emissions from the use of cutback asphalt are incurred by using emulsions in place of cutback asphalt. These costs include:

- Changes in equipment for applying emulsions in place of cutback asphalt
- Training of personnel to work with asphalt emulsions in place of cutback asphalt.

Additionally, if every state incorporates the RACT guidelines, additional plant capacity to produce asphalt emulsions would have to be created.

Costs were determined from analyses of the studies listed in the previous section and from interviews with asphalt trade associations, government agencies and producers and users of cutback asphalt and emulsions. These differential costs of replacing cutback asphalt with asphalt emulsions were then extrapolated to the non-attainment counties in the state.

17.1.5 Economic Impacts

The economic impacts were determined by examining the effects of conversion to emulsion asphalts on: the costs of paving and road maintenance; the price of cutback and emulsion asphalts; the supply and demand for these asphalts; the employment of workers in end-use applications; and on labor productivity in end-use applications.

17.1.6 Quality of Estimates

Several sources of information were utilized in assessing the emissions, cost and economic impact of implementing RACT for the use of cutback asphalt. A rating scheme is presented in this section to indicate the quality of the data available for use in this study. A rating of "A" indicates hard data (i.e., data that are published for the base year); "B" indicates data that were extrapolated from hard data; and "C" indicates data that were not available in secondary literature and were estimated based on interviews, analyses of previous studies and best engineering judgment. Exhibit 17-1, on the following page, rates each study output listed and the overall quality of the data.

EXHIBIT 17-1
U.S. Environmental Protection Agency
DATA QUALITY

Study Outputs	A Hard Data	B Extrapolated Data	C Estimated Data
Industry statistics	X		
Emissions		X	
Cost of emissions control		X	
Statewide costs of emissions			X
Economic impact		X	
Overall quality of data		X	

Source: Booz, Allen & Hamilton Inc.

17.2 INDUSTRY STATISTICS

This section presents information on the cutback asphalt industry, statewide statistics of cutback asphalt use, and comparison of cutback asphalt consumption to the statewide value of wholesale trade. A history of the use of cutback asphalt is also discussed. Data in this section form the basis for assessing the technical and economic impacts of implementing RACT in Tennessee.

17.2.1 Industry Description

The cutback asphalt industry encompasses the production and use of cutback asphalt. Cutback asphalt is one product resulting from the refining and processing as asphalt from crude oil. Cutback asphalt is produced from refined asphalt and petroleum liquids at an asphalt mixing plant. It is then stored in tanks or loaded into tank trucks and sold to the end users, primarily state highway organizations and construction contractors.

17.2.2 Size of the Cutback Asphalt User Industry

This report addresses the size of the cutback asphalt user industry in Tennessee. Although cutback asphalt may be produced in Tennessee, the production industry is not the focus of this study since RACT requires control of the use of cutback asphalt. Fourteen thousand nine hundred fifty-six tons of cutback asphalt were purchased in Tennessee in 1977 at a value of $1.4 million. The value is based on an estimated average price per gallon of $0.36.

Though the uses of cutback asphalt in Tennessee are well documented, hard data on the number of employees involved in cutback paving operations are not currently available. Still, it is possible to make a reasonable estimate of the number of employees based on data found in the Department of Commerce County Business Patterns.

It is estimated that statewide approximately 925[1] people are engaged in operations where cutbacks can be used.

17.2.3 Comparison to Statewide Economy

The ratio of value of shipments of cutback asphalt to the statewide value of wholesale trade in Tennessee is less then 0.02[2] percent.

17.2.4 Demand for Cutback Asphalt

In the 1920's and 1930's, the increasing sales of automobiles stimulated highway construction. The need for low-cost pavement binders which provided weather resistance and dust-free surfaces became apparent during this building cycle. Cutback asphalts emerged to fill this need. After World War II, the sale of cutback asphalts remained at an almost constant level. Since 1973, the use of cutback asphalt has decreased. Exhibit 17-2, on the following page, shows national sales from 1970 to 1976 of cutback asphalt, asphalt cement, and asphalt emulsions.

17.2.5 Prices of Products and Costs of Usage

Historically, cutback asphalts have been up to 10 percent more expensive per gallon than asphalt emulsions. In recent years, this differential has been negligible; however, in the past two years the historical price disadvantage has begun to reemerge.

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[1] Statewide, approximately 4,801 people were employed in highway and street construction. It is assumed that the number of people employed in cutback and emulsion applications is proportional to the 4,801 people in the same ratio as most of 1977 state sales of cutbacks and emulsions to 1977 state sales of all petroleum asphalts and road oils. At an estimated ratio of 19 percent, the employment statewide is approximately 925. See County Business Patterns 1976: Tennessee, U.S. Department of Commerce CBP-76-12, 1978, p. 3.

[2] Source: U.S. Department of Commerce, Bureau of the Census

EXHIBIT 17-2

U.S. Environmental Protection Agency
HISTORICAL NATIONAL SALES OF ASPHALT CEMENT, CUTBACK ASPHALT AND ASPHALT EMULSIONS

YEAR	ASPHALT CEMENT		CUTBACK ASPHALT		ASPHALT EMULSIONS		TOTAL
	Use of (000 of tons)	Percent of Total	Use of (000 of tons)	Percent of Total	Use of (000 of tons)	Percent of Total	Use of
1970	17,158	72.7	4,096	17.4	2,341	9.9	23,594
1971	17,612	73.8	3,994	16.7	2,275	9.5	23,821
1972	18,046	74.2	3,860	15.9	2,399	9.9	24,305
1973	20,235	74.8	4,220	15.6	2,585	9.6	27,040
1974	19,075	77.4	3,359	13.6	2,208	9.0	24,642
1975	16,324	75.7	3,072	14.2	2,197	10.1	21,593
1976	16,183	75.3	3,038	14.2	2,254	10.5	21,474

Source: U.S. Bureau of Mines

The comparison between cutbacks and emulsions is somewhat different when one looks at quantity requirements. Though technically interchangeable in many applications, it is typically the case that more emulsion must be applied than cutback for an identical task. This is because emulsions have a lower asphalt content than cutbacks on a per gallon basis. Estimates on quantity conversions (substitutability) range from one-to-one to one-to-two in favor of cutbacks depending on the type of emulsion and the given application.

However, in terms of average cost of usage, currently, price and quantity differentials tend to be offsetting. Thus the cost of usage should be approximately the same.

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[1] Interview materials from The Asphalt Institute, College Park, Maryland

[2] Ibid. Contentions that the price per mile of emulsions is cheaper than oil-based asphalts are currently being made. Though true, the contention is misleading because the comparison is between hot mix asphalts and emulsions in overlay applications. Cutbacks are not used in overlay applications.

17.3 THE TECHNICAL SITUATION IN THE INDUSTRY

This section presents information on the use and production of asphalt. The sources and characteristics of VOC emissions from the use of cutback asphalt are then described and are followed by: estimated statewide VOC emissions from the use of cutback asphalt; the VOC control measures required by RACT, and the VOC emission control procedure for use of cutback asphalt in Tennessee.

17.3.1 Asphalt: Its Production and Uses

Asphalt is a product of the distillation of crude oil. It is found naturally and is also produced by petroleum refining. In the latter instance, the crude oil is distilled at atmospheric pressure to remove lower boiling materials. Nondistillable asphalt is then recovered from selected topped crude by vacuum distillation; oil and wax are removed as distillates; and the asphalt is left as a residue. Asphalts can be produced in a variety of types and grades ranging from hard brittle solids to almost water-thin liquids. The type of asphalt produced depends on its ultimate use.

Asphalt is used as a paving material and in a wide range of construction applications. The cutback and emulsion asphalts that are the object of RACT legislation are paving materials used primarily in spraying and cold mix patching operations. For further information on asphalt production and use the reader is referred to: A Brief Introduction to Asphalt and Some of Its Uses, The Asphalt Institute, 1977.

17.3.2 Sources and Characteristics of VOC Emissions From the Use of Cutback Asphalt

Hydrocarbons evaporate from cutback asphalts at the job site and at the mixing plant. At the job site, hydrocarbons are emitted from equipment used for applying the asphaltic product and from road surfaces themselves. At the mixing plant, hydrocarbons are released during mixing and stockpiling. The largest source of emissions, however, is the road surface itself. In Tennessee, cutback asphalt is used in the construction and maintenance of secondary roads throughout the state.

It is the petroleum distillate (diluent) in the cutback asphalt that evaporates. The percentage of diluent that evaporates depends on the cure type.

The evaporating diluent in the three types of cutback asphalt constitutes the following percent of the asphalt mix by weight:

- Slow cure—25 percent
- Medium cure—70 percent
- Rapid cure—80 percent.

17.3.3 Statewide Emissions

Total emissions from the use of cutback asphalt in Tennessee during 1977 are estimated to be 3,075 tons. But given permitted RACT exemptions on cutback curtailment, only 1,540 tons will be subject to control.[1] See Exhibit 17-3 for details.

17.3.4 RACT Guidelines and the Implications of Their Implementation

The RACT guidelines specify that the manufacture, storage and use of cutback asphalts may not be permitted unless: long-life storage is necessary; application at ambient temperatures below 50°F is necessary; or application as a penetrating prime coat is necessary.

Given these exemptions, general experience with asphalt emulsions in several regions of the U.S. indicates that emulsions are adequate substitutes for cutbacks.[2] Moreover, the same equipment that is used to apply cutback asphalt can be used with asphalt emulsions after minor modification. The few changes necessary to replace cutback asphalt with emulsion asphalt are as follows:

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[1] Representatives of the Tennessee Department of Transportation, Bureau of Highways indicated that RACT exemptions could account for 50% of current cutback usage.

[2] It is reported that emulsions cannot be applied in the rain. This is also true for rapid and medium cure cutbacks.

It is the petroleum distillate (diluent) in the cutback asphalt that evaporates. The percentage of diluent that evaporates depends on the cure type.

The evaporating diluent in the three types of cutback asphalt constitutes the following percent of the asphalt mix by weight:

- Slow cure—25 percent
- Medium cure—70 percent
- Rapid cure—80 percent.

17.3.3 Statewide and Non-Attainment Area Emissions

Total emissions from the use of cutback asphalt in Tennessee during 1977 are estimated to be 3,075 tons. But given permitted RACT exemptions on cutback curtailment, only 1,540 tons will be subject to control.[1] See Exhibit 17-3 for details.

17.3.4 RACT Guidelines and the Implications of Their Implementation

Presently, the State of Tennessee is preparing draft legislation on the use of cutback asphalt which will be modeled after the RACT guidelines.

The RACT guidelines specify that the manufacture, storage and use of cutback asphalts may not be permitted unless: long-life storage is necessary; application at ambient temperatures below 50°F is necessary; or application as a penetrating prime coat is necessary.

The Tennessee guidelines are quite similar in most respects, but there are some minor differences. The current draft of the Tennessee guidelines specifies that cutback asphalts used in paints will also be exempt. In addition, the exemption for maintenance patching when ambient temperatures fall below 50°F is modified to allow for curing time.

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[1] Representatives of the Tennessee Department of Transportation, Bureau of Highways indicated that RACT exemptions could account for 50% of current cutback usage.

EXHIBIT 17-3
U.S. Environmental Protection Agency
ESTIMATED HYDROCARBON EMISSIONS FROM USE OF CUTBACK ASPHALT IN TENNESSEE

	Sales[a] of Cutback Asphalt (000 Tons)			Estimated Hydrocarbon Emissions in 1977 (000 Tons)				Estimated Non-Exempted Hydrocarbon Emissions in 1977 (000 Tons)
	Rapid Cure	Medium Cure	Slow Cure	Rapid Cure	Medium Cure	Slow Cure	Total	
State	9.72	5.24	0.0	1.98	1.09	0.0	3.08	1.54[b]

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[a] Source: U.S. Department of Energy, Bureau of Mines

[b] 50 percent of emissions are from non-exempted cutbacks. See footnote (a) to section 17.3.3.

Given these exemptions, general experience with asphalt emulsions in several regions of the U.S. indicates that emulsions are adequate substitutes for cutbacks.[1] Moreover, the same equipment that is used to apply cutback asphalt can be used with asphalt emulsions after minor modification. The few changes necessary to replace cutback asphalt with emulsion asphalt are as follows:

- Retrain employees on the use of asphalt emulsions
- Modify cutback asphalt equipment to accommodate asphalt emulsions, including:
  - Providing new nozzles on the distributor truck which applies the asphalt
  - Adjusting the pumps which apply the emulsion
  - Cleaning equipment prior to using emulsion
- Create emulsion plant capacity to meet the increased demand
- Provide asphalt manufacturing facilities with venting for steam.

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[1] It is reported that emulsions cannot be applied in the rain. This is also true for rapid and medium cure cutbacks.

17.4 COST AND HYDROCARBON REDUCTION BENEFIT EVALUATIONS FOR RACT REQUIREMENTS

Costs for using asphalt emulsions in place of cutback asphalts are presented in this section. Each cost item is discussed, quantified, and then the total cost is calculated for the state.

17.4.1 Costs Associated With Using Asphalt Emulsions in Place of Cutback Asphalt

The information on the costs of using asphalt emulsions in place of cutback asphalt was gained from interviews with asphalt trade association members, asphalt manufacturers, and from analysis of existing studies on asphalt.

Costs to users of cutback asphalt who must convert to emulsions are primarily those expenditures associated with retraining personnel and making minor equipment modifications. The existing price/gallon advantage accruing to emulsions is approximately offset by the quantity advantage accruing to cutbacks (in terms of required asphalt content and comparative durability). Put differently, expenditures on materials should remain approximately constant, but those on capital and labor should increase as users convert to asphalt emulsions.

The most significant cost to the user will be for retraining personnel in the methods of asphalt emulsion application. It is estimated that these training costs are $300 per person including the cost of supervision for the training session.

Modification of trucks used in applying asphalt consists of replacing nozzles at a cost of $5 per nozzle. An average truck is equipped with 30 nozzles; therefore, the cost per truck would be $150. Other equipment costs include adjusting pumps and cleaning equipment before asphalt emulsions can be applied, and these are considered to be minimal.

Total user costs are assumed to be incurred on a one-time basis. Minor equipment costs are generally not capitalized but are expensed in the accounting period in which they are incurred. The paragraph which follows shows total costs to the non-attainment counties for converting from the use of cutback asphalt to asphalt emulsion.

17.4.2 Extrapolation to the Statewide Industry

Converting from cutback asphalts to asphalt emulsions in the state is estimated to cost $26,768. This translates into $17 per ton of hydrocarbon emissions reduced. A summary of these costs is given in Exhibit 17-4 on the following page.

EXHIBIT 17-4
U.S. Environmental Protection Agency
COSTS IN TENNESSEE FOR APPLYING RACT TO THE USE OF CUTBACK ASPHALT

Direct Cost Summary

Cutback asphalt used in the state (tons per year)	14,956
Potential emissions reduction[a] from converting to use of emulsion asphalt (tons per year)	1,540
Retraining costs[b]	$21,368
Total one-time costs	5,400
One-time costs per ton of emissions reduced	$ 17.
Annualized cost per ton of emission reduced	0

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[a] Assumes 50% of cutback usage will be exempted, and emulsion asphalt substituted will have no VOC emissions.

[b] Retraining costs are calculated in two stages. First, it is assumed that the percent of the labor force unfamiliar with emulsion application will be roughly equal to a proxy ratio which relates sales of cutbacks to sales of cutback plus emulsions in 1977. Since the sales of cutbacks were 14,956 short tons and those of emulsions 179,087, the proxy ratio is about one-thirteenth. Second, this proxy ratio is multiplied by the estimated total labor force (925) and the cost per person ($300).

[c] Representatives of national asphalt organizations have suggested that for every two workers there is approximately one distributor truck. This implies that 36 trucks will need modification at a cost of $150 per truck.

Source: Booz, Allen & Hamilton Inc.

17.5 ECONOMIC IMPACTS

This section discusses the economic impacts associated with applying RACT to the use of cutback asphalt in Tennessee. The direct economic impacts include:

- User Cost—The estimated one-time cost of $26,768 distributed statewide in Tennessee is small compared to the $278,329,000 spent on highway construction and maintenance during 1977.[1]

- Price—The prices of cutback and emulsion asphalts may be marginally affected by RACT to the extent that demand and supply shifts for both products are not offsetting. However, it is not RACT but rather the increasing cost of diluents used in cutbacks which will have the most decisive impact on price differentials in the future.

- Demand—If current usage patterns prevail through 1981 when RACT is scheduled for implementation, then the demand for cutbacks might fall off by 50 percent while the demand for emulsions rises by 4 percent.

- Employment—No change in employment is predicted from implementing RACT, although it will be necessary to retrain approximately 72 employees in Tennessee on the use of asphalt emulsions.

- Productivity—Given appropriate retraining, worker productivity is not expected to be affected by handling more emulsion asphalts.

In addition to direct impacts there may also be indirect effects. Implementing RACT may cause a strain on current industry capacity to meet the increased demand for emulsion asphalts. To the extent that a supply-demand imbalance is inherent, it may be necessary for producers to invest in new plant capacity. Presently, it is anticipated that sufficient lead time exists for any supply-demand imbalance to be redressed. Insufficient data are available to quantify these potential costs in Tennessee.

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[1] Source: Federal Highway Administration. A small fraction of this cost includes depreciation on equipment.

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Exhibit 17-5 presents a summary of the findings in this report.

EXHIBIT 17-5
U.S. Environmental Protection Agency
SUMMARY OF DIRECT ECONOMIC IMPLICATIONS OF IMPLEMENTING RACT FOR USE OF CUTBACK ASPHALT IN THE STATE OF TENNESSEE

Current Situation	Discussion
Use of cutback asphalt	In 1977, use of cutback asphalt was 14,956 tons in the state.
Indication of relative importance of industrial sector to state economy	1977 sales of cutback asphalt were estimated to be $1.4 million.
Current industry technology trends	Nationally, use of cutback asphalt has been declining.
1977 VOC emissions (actual)	3080 tons annually; 1,540 of which would be controled under the proposed regulations.
Industry preferred method of VOC control to meet RACT guidelines	Replace with asphalt emulsions
Assumed method of control to meet RACT guidelines	Replace with asphalt emulsions

Affected Areas in Meeting RACT	Discussion
Capital investment	$0.03 million
Annualized cost	No change in paving costs are expected.
Price	No change in paving costs are expected.
Energy	No savings to user[a]
Productivity	No major impact
Employment	No major impact

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[a] It is estimated that an energy savings of 14,989 barrels of oil equivalent could accrue to the manufacturer. The total energy associated with manufacturing, processing and laying one gallon of cutback is approximately 50,200 BTUs/gallon. For emulsified asphalts, it is 2,830 BTUs/gallon. One barrel of oil equivalent is assumed to have 6.05 million BTUs, and one ton of cutback asphalt is assumed to have 256 gallons.

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